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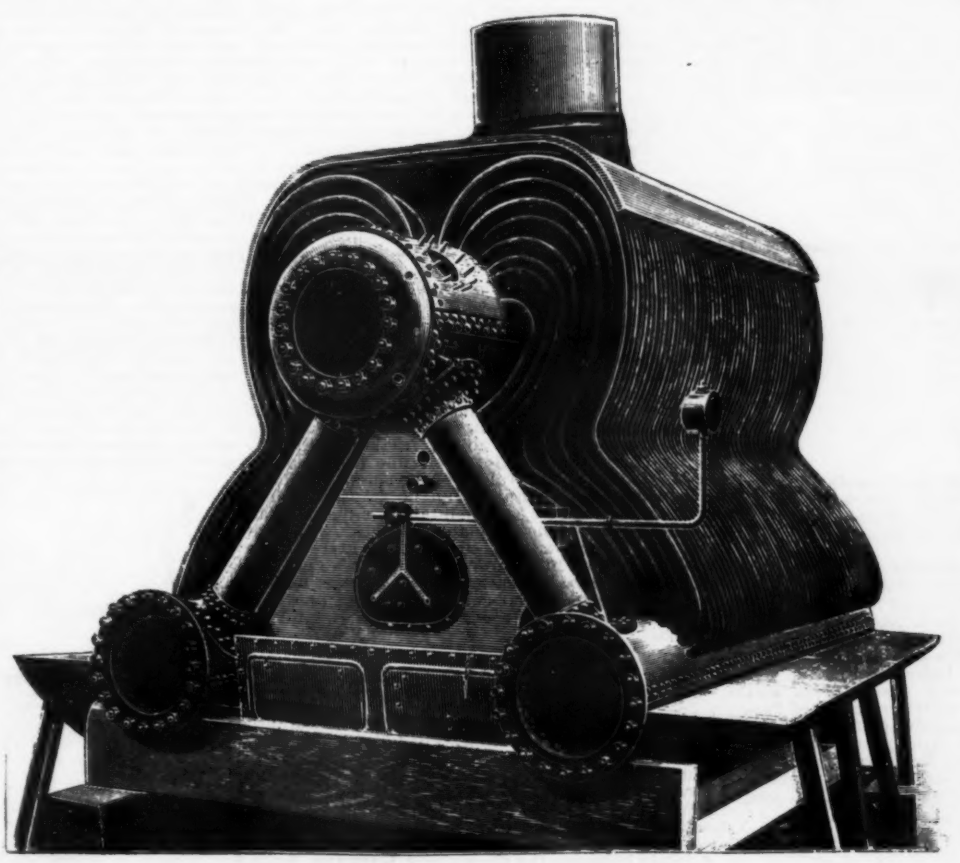
H. M. S. SPEEDY.

THE exhaustive series of trials of this vessel which have taken place recently being now concluded, we are enabled to give their details and the results attained thereat. The Speedy is one of the new first-class torpedo gunboats ordered under the Naval Defense Act of 1889; and although of the same general design and dimensions as other sister ships of the same class, she is of more than ordinary interest, in being the largest warship ever built on the Thames above London Bridge, and the first ship in the British navy fitted with a special type of water tube boilers.

The Speedy was built and engined by the now well known Chiswick firm, Messrs. Jno. I. Thornycroft & Co., of torpedo boat fame, and the exhaustive series of trials which she has lately undergone were more especially directed to the testing of the capabilities of the patent water tube boilers invented by Mr. Thornycroft with which she is fitted, and which were guaranteed to develop under forced draught 1,000 indicated horse power more than that promised by other contractors in sister ships of the same class, and this without any increase of weight in her propelling machinery. As the speed and boiler trials of the vessel promised to be of exceptional interest, they have been attended by a more than ordinary gathering of representative gentlemen, which included the naval attaches of the French, German, and Austrian governments, the engineers-in-chief of the German, Austrian, and Italian navies, the chief engineers of the torpedo departments at Kiel, with several officers of her Britannic Majesty's navy, and other interested experts in boiler engineering and naval architecture.



WATER TUBE BOILER, CASING REMOVED, H. M. S. SPEEDY.

At the trials the British Admiralty was represented by Mr. Deadman and Mr. Pledge, of the constructive department, and Mr. Oram and Mr. Butler, engineer inspectors; Sheerness dockyard by its chief and assistant engineers; the Steam Reserve by Mr. Moon; and the contracting engineers and builders by Mr. John I. Thornycroft and Mr. J. Donaldson, the former assisted by Mr. Geo. Brown, taking charge of the machinery.

To insure all boiler and engine connections being in order, a preliminary run with the vessel was made on September 28, when, all being found satisfactory, on her return the boilers were filled with water locally obtained, in readiness for a full power trial under natural draught. Steam having been got up to 200 lb. pressure per square inch, in from twenty-five to thirty minutes from the time of lighting fires, on the morning of October 3, the vessel, under the command of Captain Douglas, R.N., of the Steam Reserve, left her anchorage and proceeded to sea. When deep water was reached, the trial was entered upon and continued for eight consecutive hours, and gave the following mean results: An ample supply of steam at a pressure of 183·3 lb. per square inch was easily maintained, with a full ½ in. of air pressure in the stokeholds, and with the vacuum at 27½ in.; the engines made 204·6 revolutions per minute, and developed 3043·7 indicated horse power, the port engines giving off 1438·2 horses, and the starboard 1605·5; the resultant speed of the vessel—which had at the time a mean draught of 9 ft. 8½ in.—being 18½ knots per hour by log.

Some little trouble having been experienced on this trial with the Sheerness water used in the boilers, it was decided that in any further runs, none but distilled or fresh water should be used for steaming purposes. This being supplied, and some necessary alterations having been made in her steering gear, she left Sheerness on October 20 for a preliminary trial under forced draught. On this occasion, as on the previous trials, the boilers steamed admirably, a full supply at 190 lb pressure per square inch being maintained with 1¼ in. of air pressure, the power developed by the engines was 4,390 horses, and the vessel was making 20·4 knots per hour when one of the starboard engine crank pins was found to be getting hot, and necessitated a stoppage. After examination it was decided to postpone the trial for the day and to return to Sheerness. The vessel was accordingly put about, and the run back showed to great advantage the superiority of the twin over the single screw system of propulsion; for with one set of engines only in use, and some of the boilers nearly shut off, the vessel maintained for over three hours an average speed of 11 knots while covering the distance back to her anchorage.

After readjustment of the crank pin brasses and lubricators, the Speedy again left Sheerness at 8 A. M. on the 26th October, and proceeded to sea for the official three hours' full power trial under forced draught. It having been deemed necessary for the ship to be in deep water before commencing the trial, about forty miles had to be run before reaching the trial ground and setting the log. While covering this distance, a favorable opportunity was afforded of noting the apparent ease with which the boilers responded to the requirements of the engines for a larger supply of steam as their speed and that of the ship increased. When finally on the trial, with steam at 200 lb. pressure per square inch and the engines making 245 revolutions per minute for four consecutive half hours they developed 4564·5, 4674·6, 4685·9 and 4708·1 indicated horse power respectively, and the ship a speed of 21 knots, but while running the fifth half hour it was found that the boilers were being fed by salt water, caused by a leakage in one of the condensers. On this being discovered it was decided to return to Sheerness.

On Tuesday last the final official trial of the Speedy was completed. She left Sheerness at 8 A. M., and proceeded to sea. In an hour and a half, in rather shallow water—the weather being very rough—a continuous trial of three hours' duration under forced draught was undergone, with the following results: Steam of a pressure of 193·6 lb. per square inch was maintained with easy firing of the boilers by 1·7 in. of air pressure: the starboard engines made 247 and the port 243 revolutions per minute respectively, the vacuums being 27¼ in. and 27 in., and the total indicated horse power developed by them was 4674·7, giving the ship—which at the time had a mean draught of 9 ft. 7 in.—a speed of 20 knots an hour by log, against a heavy sea. There was not the least priming of the boilers throughout the trial; and it was evident from their working that, with a greater air pressure, they were capable of developing a much larger power than that given out by them during the run.

The principal dimensions of the Speedy are: Length, between the perpendiculars, 230 ft.; breadth, 27 ft.; and displacement, at a load draught of 8 ft. 9½ in., 810 tons. Her propelling machinery, supplied and fitted by her builders, is of the same type and dimensions as fitted to the other gunboats of the Jason class, viz.: Triple expansion three cylinder twin engines, each driving a gun metal propeller 8 ft. 3 in. diameter. The engine cylinders are 22 in., 34 in., and 51 in. diameter, the piston stroke of each being 21 in.; they are each carried independently on forged steel columns, firmly bolted to continuous girders to which the crank shaft bearings are attached. The high pressure cylinders are fitted with piston valves and the intermediate and low pressure with ordinary slide valves. The engines being intended to run at a maximum of 250 revolutions per minute, with a steam pressure of 200 lb. per square inch, are fitted with large bearing surfaces throughout, and to prevent vibration are stayed to each other and the longitudinal and athwartships bulkheads by steel stay rods. They have been designed to develop 4,500 indicated horse power under forced draught and 2,500 under natural draught.

Steam is generated in eight boilers of the special water tube type invented by Mr. Thornycroft, having a total heating surface of 14,720 square feet and a grate surface of 204 square feet. As will be seen from the illustration we give of one of these boilers, its special feature is the generation of steam from water contained within instead of outside of a number of tubes of small internal diameter, arranged in rows in such a way that the inner ones form what would be the crown of the fire box, and the outer ones the shell, of an ordinary boiler; the tubes being by a simple alternation of their ends made to lie so close together that none of the products of combustion can pass directly outward. The products of combustion have, therefore, to pass among the tubes which are not in contact, between the inner and outer tiers.

A great saving of weight of water, etc., is effected, the boilers fitted in the Speedy when full being some 20 tons lighter than those of other gunboats of the same size. With this decrease in weight there is also the further advantage of an increase in stoking space, there being in the Speedy ample room for the examination of the tubes of any one of her boilers, although double the number, but occupying only the same space as those in other vessels of her class. As the heat developed by the combustion of the fuel in this type of boiler is mainly absorbed by the steam-generating tubes, and is prevented by their peculiar arrangement, as shown, from passing to the outside, and causing a radiation of heat into the stokeholds, their temperature, during the exhaustive trials of the vessel just completed, will compare very favorably with that experienced in similar gunboats fitted with boilers of the locomotive type. The advantages claimed by Messrs. Thornycroft for the water tube boilers fitted by them in the Speedy have, we think, been fully realized in the trials of the vessel now so satisfactorily concluded. The results attained have specially brought out the following points in their favor: Ease and rapidity with which steam can be raised to any pressure within the limits for which they are constructed, shown by the time occupied in effecting this, at the commencement of the trials. Freedom from leakage, proved by the behavior of the generating tubes under the extremes of temperature and pressure to which they have been subjected. The absence of priming caused by the good circulation of the water was particularly marked, and the large and very effective heating surface, causing the heat developed by combustion to be given off by the waste gases before they enter the funnels, and thus prevent the emission of flame or unburnt fuel, has proved the boilers to be very economical in coal.

As the navy stokers engaged on the above recorded trials of the Speedy were men having no experience whatever of the special type of boilers they were called

upon to stoke, the results attained cannot be considered otherwise than highly satisfactory, it being asserted by some critics, who consider themselves entitled to be judges in such matters, that it is the contractor-trained stokers alone who can obtain good results on such trials, results, they say, which are never repeated by navy stokers.—*The Engineer, London.*

THE SOLUTION OF THE FLIGHT PROBLEM.*

By KARL BUTTENSTEDT.

IT was calculated by Babinet, at the beginning of this century, and, of course, on approved mathematical data, that for purposes of flight a man would require about twenty-five times as much power as he possesses; and now, at the close of the century, the

FIG. 1.

mathematician Parseval calculates that, approximately, eight horse power would be required. These "infallible" calculations by the scientists have been the real hindrances to practical effort. I ask any thinking observer of nature, who has watched the slowly upward-circling stork, which ascends without any appreciable wing motion, whether the bird gives him the impression of expending any such force (relatively to his weight) in flight? If not, what aid may we expect from a scientific theory which does not conform to the actual facts?

As Eugen Kresz shrewdly remarks: "We possess in the science of flight technics a stately theoretical structure, but, unfortunately, without any sure foundation, so that it is to be feared that, with the practical solution of the problem, the proud theoretical structure will fall to pieces." There are purely practical, elementary problems, sublime beyond all bold-soaring theories. Such an elementary problem is the problem

FIG. 2.

of flight, which presents itself to the observing eye as one of the most simple, mechanical, physical acts of winged creatures. And what a complicated, confused caricature has theory made of this simple phenomenon!

That extraordinary vehicle, the bicycle, was, for example, discovered without mathematics, without theories, and what a splendid achievement it now is!

This affords an instance of what a man can do with his one-seventh horse power when he is put to it; and it is another good sign for the solution of the flight problem, that specialists like Lilienthal, Kresz, von Miller-Hauenfels, Kreisz, Mewes, Bosse, Milla and others, hold opinions entirely opposed to those of Parseval, and believe that man is capable of flight by his own unaided strength. "Late experiments teach us," says Lilienthal, in vol. 5 of the *Zeitschrift fur Luftschiffahrt*, 1893, "that light and strong motors might be utilized, but that the problem of aerial navigation does

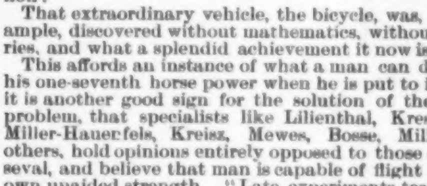


FIG. 3.

not depend on them;" and this remark indicates clearly that this tangled problem is in a fair way of being unraveled. Now that we really begin to apprehend the merits of the problem, we are in a fair way of accomplishing its solution. Hargraves' model, by means of 42 strokes of its little elastic wings, made a horizontal flight of 146 meters, and Lilienthal himself flew 80 meters against a strong wind, several times resting, for seconds, in the air, after springing to a height of 10 meters. Engineer Koch also succeeded in flying a short distance, and Professor Langley's model rose by means of two screws.

It is, hence, evident that we have at length found the clew that will guide us out of this labyrinth of confusion. What is now needed is to define clearly the simplest essentials of individual flight. That achieved, there will be no difficulty in constructing apparatus for the transport of two, five or a hundred persons. The task must be accomplished gradually, as the bird learns to fly. Nature does not advance *per saltum.*

As the greatest mechanical discoveries rest on the co-operation of a sum of trifles, so the whole problem of bird flight rests on a trifle, that is, on the pressure of the atmosphere on a suitable oblique surface. The most suitable would be, as in the case of the bird's wings, of elastic quill feathers. The end portion of such a surface is made as follows: To a tube, elastic feathers wrapped in some woven material are attached. In a condition of rest the tube or bamboo lies as in the design, Fig. 1. By beating the air, as in a wing stroke, the elastic surface, under the influence of the wind, adjusts itself obliquely to the direction of the stroke, in the same manner as the wings of a windmill stand obliquely to the direction of the wind. But, since, in the flying machine, we hold the tube firmly in the hand, it bends toward the right, and the column of air underneath the oblique surface is thrown, ray-like, to the left. The resistance which this radiating air opposes to the movement of the wings is the same force which presses their oblique surface to the right. The measure of this force is precisely the same as the elasticity of the bamboo or tube. The tube registers exactly the force of the stroke, and, thereby, also the strength of the atmospheric pressure, in the form of the translation of the force of the stroke into force of elastic tension. The stronger the stroke and the movement of the surface against the atmospheric pressure, the stronger is the elastic curvature of the tube. This bending of the tube results, whether we move the surface against the wind, or hold the surface still and let the wind blow against it, as in a sailing ship or a windmill. Just conceive for yourself, as in Fig. 1, a man suspended under two light, elastic, windmill wings, made of a bamboo with quill feathers attached. The man springs like a condor from an eminence. Suppose there were no wind, the man begins to move downward, but the surface of the wings, under which he hangs, meets a pressure from below. It is precisely the same as if there were an atmospheric pressure from below, upward. The consequence is that the points of the wings bend upward; and now, in the same manner, the air underneath rushes backward; for this falling is really a soft stroke movement. The wing surfaces are expanded horizontally, because the heavy body of the man cannot be so easily arrested in its falling movement as the rapidly moving wing points demand. If the man is heavier than the average, the initial falling movement is quicker, the corresponding atmospheric pressure proportionately stronger, and, consequently, the tension, also. But, the tension is the equivalent of the sailing power and, the conditions being equal, a heavier body will sail more rapidly than a lighter body. With such wings, it would be impossible to fall perpendicularly; the body would glide forward like a sailboat; and, in the case of a bird, to such an extent that it can sail almost horizontally without an effort. It cannot pause in its flight, its force of gravitation would at once carry it downward; this would generate atmospheric pressure upward, which would again waft it on its way.

As accessories to the sailing wings, the aeronaut will require a pair of smaller leg sails, with which he can both propel and steer himself. These can be practically operated like a screw, as in Fig. 3. It need not be supposed that this extension and operation of the wings and arms is in any sense exhausting. On the contrary, the sailing surfaces are always opposed to the point from which the wind blows, and the legs, instead of having to support the flying attachments, will be supported by them.

To solve the riddle of bird flight in a few words, it is, in my view, nothing but the translation of the force of gravity into sailing power. In this translation, nothing is lost beyond what is due to the friction of the air. When this trifling loss of power, due to friction, is compensated by an equivalent of the aeronaut's force, the whole force of gravitation can be transposed into floating power, and we can maintain our flight for an indefinite period. The aeronaut has in the weight of his own body a powerful motor for flight, and requires the exercise of but little power to maintain him in motion; he could certainly sustain the exercise as long as a wheelman could keep going. But that he would travel much faster than the wheelman is beyond all question.

* Translated and condensed for the *Literary Digest* from a paper in *Der Stein der Weisen*, Vienna, Heft 21.

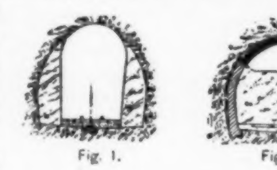
THE SECOND TRACK OF THE ST. GOTHARD RAILROAD.

IN May, 1893, the second track of the St. Gothard Railroad was opened for traffic. The following account of its construction is abstracted from a recent paper by the chief engineer of the railroad, Mr. Schrafl, in the *Schweizerische Bauzeitung.* To convey an idea of difficulties encountered in this work, we give a short description of the first track of the St. Gothard Railroad.

A treaty betweeen the three states, Germany, Switzerland and Italy, that are most interested, was made in 1871 to aid the building of a St. Gothard railroad by actual payments of the cost and by guarantees of interest. The construction was then commenced on the basis of several surveys begun in 1856. The railroad was completed in 1882. The great St. Gothard tunnel, being the most important work, had been first located. Its highest point is 3,785 ft. above sea level, and the respective elevations of the initial and terminal ends are 1,365 ft. and 700 ft. The ascent on the northern side is made through the Reuss Valley and on the southern side through the Tessin Valley. Neither of the valleys has cross valleys which could be made available for the development of the railroad line; they are inclosed by high and precipitous mountains which have an average slope of 30 deg. to 45 deg. The mountains consist of hard gneissic granite, in which are embedded softer strata of micaceous schist, of mica slate and of slate and limestone.

The total length of the St. Gothard Railroad is 159 miles, and the line may be divided into five distinct divisions, the two valley lines, the two mountain lines or ramps, and the great tunnel itself. The northern ramp commences at Erstfeld at an elevation of 1,520 ft. above sea level, and extends to Goeschenen, 3,645 ft. high, to the northern entrance of the Gothard tunnel, a distance of 12·25 miles. The fall of the valley varies from 63 ft. to 285 ft. per mile. The tunnel ends at Airolo in the Canton Tessin at an elevation of 3,755 ft. from where the road descends the valley of the Tessin to Biasca, a distance of 21·6 miles. The difference in elevation between these two points is 2,750 ft., and the fall of the Tessin ranges between 53 ft. and 550 ft. per mile. The prime factor in the location was to follow the natural grade of the valley as long and as near to its bottom as possible and to accomplish the ascent at a few points, where there were breaks in the slope of the valley. This was done by building spiral raising tunnels, of which there are three on the northern and four on the southern ramp. The grade in the spiral tunnels is 121 ft. per mile, whereas the maximum grade otherwise was fixed at 137 ft.

The approaches Erstfeld-Goeschenen and Airolo-Biasca had originally been built for single track, but wherever the future double tracking would have been impossible after the opening of the traffic, or would have entailed considerable extra expenses, provision had been made for two tracks. For the tunnels the Pressel-Kaufmann sections were chosen, as they admit of enlargment for a second track, as shown by the illustrations, Figs. 1 and 2. A number of retaining walls



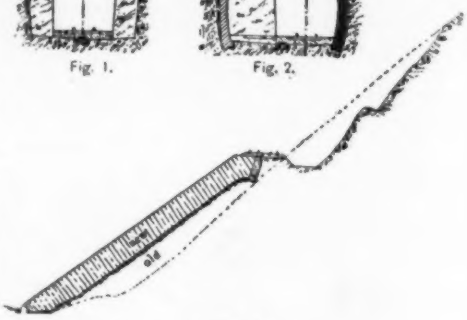


FIG. 3.

and the pier and abutment foundations of the larger bridges had been built for two tracks except where the masonry rested directly on rock. The great tunnel and four smaller ones had been arranged for double track when built. The rapid growth of the traffic of the road required the building of the second track, and in October, 1887, it was commenced, with the expectation of completing it in 1896. The continual increase of traffic made it desirable to shorten the time of construction, and the work was pushed so successfully that the second track was opened in May last.

In building the first track some definite assumptions had been made about the location of the second track, but the elaboration of detailed plans for the latter necessitated frequent deviations for reasons of economy, better acquaintance with the locality and avoidance of dangerous building operations; so that though the two tracks are parallel, in general they cross each other repeatedly. This rendered it necessary to discontinue and shift parts of the superstructure. Sometimes the roadbed was enlarged on both sides and the axis of the double track road changed accordingly. The minimum distance between centers of tracks was fixed at 11·5 ft., which is exceeded at the stations and other places. The work upon the substructure was let in short sections, to have the contractors give their personal attention to all work. Freight cars for the transport of materials, rails, fastenings, transfer and turn-

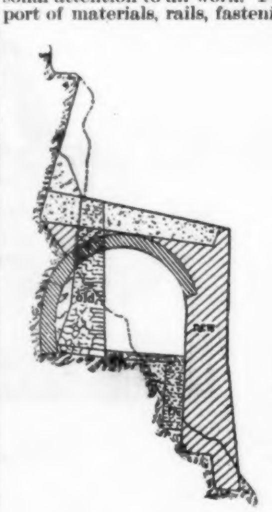


FIG. 4.

FIG. 5.

tables for the side tracking of cars were furnished by the company free of cost, and explosives were sold by them at cost price. The most difficult works were undertaken by the railroad company itself. The excavation and transport of earth and rock on the open road comprised 690,000 cu. yds. A number of high embankments on the southern approach had to be widened, and to do this work over 100,000 cu. yds. were brought down at night from Airolo, where they had been deposited during the excavation of the great tunnel. Fig. 3 shows one of these embankments, 85 ft. high. At various other embankments it was preferred to enlarge the roadbed by building dry walls at batten of 1:3 and 1:2. Of the 30 tunnels on both the ramps, only four small ones, of a total length of 930 ft., had been originally built for double track; of the others, 38,500 lin. ft. had to be enlarged and partly lined; 243,000 cu. yd. of work were excavated and 38,000 cu. yd. of masonry were built. The tunnel work was done almost exclusively at night, because the train intervals were longest then, and the smoke least bothersome. The excavated material was removed on low platform cars

of five tons' capacity, which after unloading were taken from the track by means of transfer tables. Generally two blasts were fired during the night and all debris removed before the first moving train passed. Fig. 4 shows a gallery, 120 ft. long, built at the approach of the Bristen tunnel in preference to cutting back the precipitous mountain side, which is supported by ponderous masonry pillars.

In widening masonry structures the following method was adopted. The rock projections of the existing masonry were dressed off and the new masonry built abutting against the old one. The masonry was carefully laid and periods of time were given to allow for setting. The result was that few cracks between the old and new masonry developed, and these were very insignificant ones. Fig. 5 shows a bridge pier 170 ft. high above the foundations, which has been successfully widened in the manner described. Forty-eight thousand cubic yards of masonry were required for the enlargement of bridges and culverts.

The first of the iron bridges for the second track were duplicates of those built for the first track, but later mild basic Thomas steel took the place of wrought iron, and the double intersection system, with verticals, replaced the quadruple system without verticals. Some of the single track bridges have been built in the axis of the double track road, and had to be shifted laterally. This was effected for each bridge on one Sunday between two passenger trains. No freight trains were run on Sundays, and all work that caused traffic to be interrupted for any length of time was performed on these days. For the new bridges were needed 3,100 tons wrought iron and 2,100 tons mild steel.

The superstructure of the second track consists, for the Airolo-Faido division, of steel rails, 75 lb. per yard, 39 ft. long, with 15 mild steel ties, 127 lb. for each rail; for the two other sections were used in the longer tunnels steel rails, 97 lb. per yard, 39 ft. long; otherwise such of 93 lb. weight and 39 ft. length. The ties were of mild steel, 145 lb.; 16 for each rail.

During the whole 5½ years of construction the most important function of its supervising engineers was to guard the traffic against the dangers which the proximity of the operated track with the work necessarily entailed. Special signal stations were installed and detailed instructions issued and enforced. During the night the tunnels were protected from the two adjoining depots, from which, during a previously arranged period, no train was dispatched before reliable information had been obtained that the track was clear. Each working squad was covered by electric or by hand signals. All work was stopped during the passage of trains. While the maintenance of traffic impeded work, the available track was an advantage in facilitating the transport of materials, and the continuous downgrades from both ends of the great tunnel were used for gravity railroading.

The original cost of the St. Gothard Railroad had been about $48,000,000, of which the great tunnel takes $12,500,000. The second track required an expenditure of $2,500,000 only.—*Railroad Gazette.*

A WELDLESS STEEL CHAIN.*

By M. SIMON-BRUNSCHWIG.

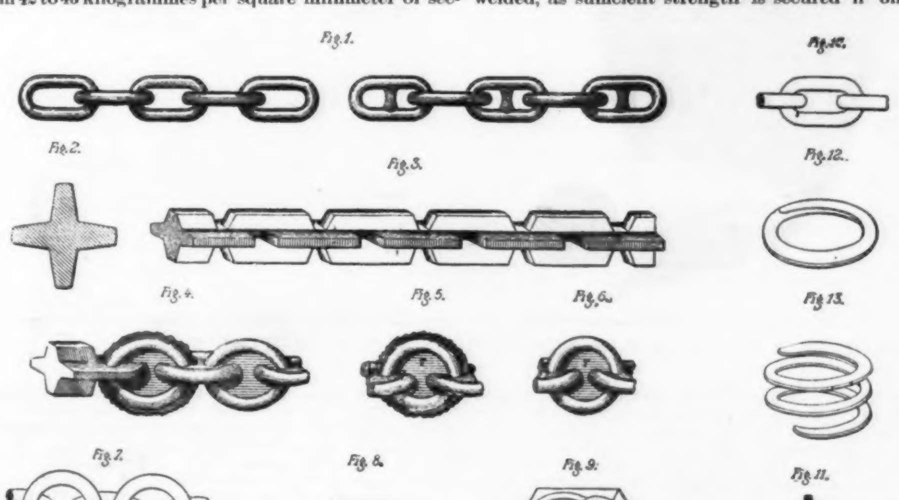
A PROCESS of manufacture of weldless steel chains, which has been devised by M. Oury, of the arsenal at Cherbourg, France, is illustrated in the accompanying diagrams. When completed it has the same form as an ordinary iron or steel chain, and cannot be distinguished by its appearance, as shown in Fig. 1. The chain itself is made without welding by a series of stamping processes under the steam hammer, from bars made of steel capable of resisting a breaking strain of from 42 to 45 kilogrammes per square millimeter of section, with an elongation of from 20 to 25 per cent. These bars are rolled in such a form as to show the section of a regular cross with four equal arms, as shown in Fig. 2. The first step is to heat the bars to a red heat in a special furnace and then pass them through a shearing machine which cuts out a portion of the metal alternately on each arm, leaving it in the form shown in Fig. 3. When this is done the small holes, the purpose of which is shown further on, are pierced in the cold bar. The bars are then reheated in the furnace, and are passed under a series of steam hammers or forging presses each carrying a special die. The successive forms assumed by the bar after each operation are shown in Figs. 4, 5 and 6. It will be seen that the action of the dies forces the metal by degrees into the form of a chain, leaving only in the center of the links a very thin plate of metal. This plate is finally cut out by a special machine. The bar is now transformed into a series of links held rigidly together which must be detached from each other. It is in preparation for this operation that the four holes referred to above were drilled. These holes, which were pierced at equal and definite distances, were placed in pairs in the same axis of the bar, as shown in Fig. 8, and are now found at the inner point of contact of the links, in such a way that the latter are held together only by four threads of metal and can be easily detached from each other. This separation is made by means of a small steam hammer, and we then have a chain of which the links are free, but are still somewhat imperfect and are circular in form. The chain must then be again heated and passed under a new series of hammers or stamps supplied with round dies, as shown in Fig. 9, in such a way as to give the links a true circular form, and to do away with the imperfections left in the preceding operation. When a link falls into the die the two adjoining ones are perpendicular to the first and take their places in the slots, A and B, Fig. 9. This operation is repeated several times in order to take away the fins and roughnesses left by the various stamping processes, and we then have a chain without a weld, formed of round and regular links, the length of course being determined by the length of the bar. The chain is then once more heated in the furnace and passed through the final press, which gives the usual oval form to the links, as shown in Fig. 10. It is then at last finished, and it only remains to cool it gradually and to submit it to the necessary test.

As soon as it is cooled each length of chain is taken to the testing machine, which has a capacity of 200 tons. Chains made of mild steel are expected to show a minimum resistance of 42 kilogrammes per square millimeter to breakage. If this test is passed, the whole length of the chain is submitted to a working load of 18 kilogrammes per square millimeter. Some very remarkable tests have been made of different lengths of chain, showing the superiority of the weldless chain of mild steel over iron chains made by the ordinary method. A special test made as to the wear of iron of good quality and the steel of which these chains were made was carried out in this way. Two bars, one of iron taken from a chain of the best quality, the other of steel of the same diameter, the same length and the same weight were placed in turn in a clamp above an emery wheel revolving at a regular speed for a period of ten minutes. The bars were then weighed to show the loss due to abrasion, when the steel showed a loss of three grammes, the iron no less than eight grammes.

As noted above, the length of the weldless chains is necessarily limited by that of the rolled bars from which they are made. In order to join two sections of this chain we must have a link of the same form which will when in place have the same resistance to breakage as the section joined. The link designed by the inventor for this purpose is shown in Figs. 12 and 13. It is formed from a bar of steel of calculated length which is wound in helical form. The ends of the two sections of chain to be joined are passed into this link while the spiral is still open. It is then heated to a white heat and the spirals are welded together, the link having the same thickness as the other links of the chain. It is brought into an oval form under the die and it is impossible afterward to pick it out by the eye. Special precautions are taken to secure a perfect weld and it sometimes happens that two heats are necessary to complete it. It is claimed, however, that it is not necessary that the whole surface should be welded, as sufficient strength is secured if only the edges of the bar are welded, and this has been shown by tests made.

In a special trial made by the engineer of the Bureau Veritas, a chain of this kind sustained without breaking a load of 110 tons, while an iron chain of the same size and of the best quality broke under a load of 83 tons. It is claimed that for hoisting and other purposes steel chains made by this process present many advantages and can be used of a much lighter weight than iron chain for the same service. There being no weld, there is no weak point. The wear by abrasion between the links is less than with an iron chain; oxidation is slower and breakage is very unlikely, as an excessive load will be made manifest by the elongation of the links before the breaking point is reached, while with the ordinary iron chain there is no such warning given.

Chains by M. Oury's process are now made by the Massardiere Forges, in France, of several different sizes, and are being introduced in several mines and other establishments in that country.



MANUFACTURE OF WELDLESS CHAINS.

* Translated and abstracted from article in the *Revue Universelle des Mines.*—*Engineering and Mining Journal.*

ARTESIAN WELL BORING IN QUEENSLAND.

THE importance of the discovery that both in Queensland and New South Wales plenty of water is to be had by the expedient of boring an artesian well can hardly be exaggerated. Day by day in the colonies fresh reports come in of the striking of artesian water in one or other of the many bores now being drilled all over the dry belt of western Queensland and New South Wales. An immense area of that territory has now been proved to be water-bearing, and drought is fast losing its terrors for the western squatter. As yet there is no indication of a diminution of the vast supply of underground water, owing to the number of vents which the hand of man has opened out for its escape, and the question whether all the boring that is likely to be done can appreciably affect the store is the subject of fierce debate among those who claim to speak with authority. Unquestionably, however, artesian water has already proved the salvation of many a pastoral property in Queensland, as well as in New South Wales, and the benefit yet to be derived is incalculable. The latest instance of success in this direction, of which news comes by a recent Queensland mail, is that Saply Downs No. 2 bore has struck artesian water at a depth of 543 ft. The flow is estimated at over 1,000,000 gallons daily. The water rises 10 in. over the 6 in. casing. This is perhaps the shallowest depth in the colony at which such a large flow has been obtained. The Tara No. 3 bore has a depth of 2,100 ft., with a flow of 220,000 gallons daily, while that at Richardson No. 1 yields 1,000,000 gallons from the comparatively shallow depth of 740 ft.

THE "RICHARDSON" BORE.

NEW METHOD OF CASTING STEEL INGOTS.

AT the Nykroppa Iron Works, in Sweden, a method of consolidating steel ingots, by subjecting the freshly filled mould to pressure developed by centrifugal action, has been introduced by the manager, Mr. L. Sebenius, according to *Stahl und Eisen.* The apparatus consists of an upright shaft in the center of a cylindrical casting pit, carrying a frame of four arms, to each of which is articulated a platform supporting four ingot moulds. While the shaft is at rest the moulds are upright, and are filled in the usual way, but when it is set in rapid rotation they fly up into the horizontal position, and a pressure in the direction of the length of the ingot is developed equal to thirty times that due to the column of liquid metal in the mould, which drives the gases out and produces a perfectly solid casting. Uniformity of composition is also induced, as on account of the rapid cooling liquation is prevented. The process, which has now been in use about two years, has been applied to both the Bessemer converter and the open-hearth furnace. The ingots are free from external defects, and the loss by defective ends has been diminished 40 per cent., the metal being so compact as to bear rolling to finished sizes without the use of the cogging mill. The cost of the apparatus is about $2,000 for a three-ton and $4,000 for a ten-ton charge.

The circumference described by the bottom of the moulds when spun up into the horizontal position is about 67 ft., corresponding with the working speed adopted of 125 revolutions to a velocity of nearly 10,000 ft. per minute. The pressure on the mould taken at 30 times the depth of the ingots will be about 150 ft. of iron, or from 500 to 600 lb. per square inch. In the form of the apparatus intended for smaller ingots the moulds are arranged on an inclined position and radially to a central fixed vertical feeding tube upon a

turntable, which is set in rotation after filling, or the latter operation may be performed while the table is actually in motion.

There is a later modification of the apparatus, in which the rotating table, being smaller in diameter than that previously adopted, can be driven at a higher speed up to 200 revolutions per minute. There are eight pivoted moulds, each divided by internal walls, so as to give nine small ingots suitable for wire billets or thin sheets. By means of a central annular funnel lined with refractory material and provided with eight feeding spouts, or one for each group of moulds, the whole number of 72 ingots is cast by a single pouring from the ladle, which contains from four to six tons of steel.

A NEW STEAM TURBINE.

STEAM has been found to be the medium best adapted for converting heat into mechanical work; its low price, simple means of production, good chemical qualities, the ease with which it is reduced to a liquid state and the comparatively small dimensions of the appliances needed, have caused its decided preference to other gases. During several generations, work has been progressing in all civilized countries for the development of the steam engine; and yet invention in this field is far from having reached perfection. Each year the consumption of steam per horse power is reduced by a fraction; each new number of the technical journals brings information of new and improved constructions of steam engines. Every constructor of engines knows that here is a vast field for the persevering work of man. To this the results of the last decade bear testimony.

Concerning the theoretical conditions for a favorable conversion of heat into mechanical work, viz., high initial temperature and high pressure, the possibilities of their being accomplished in the steam engine are very limited. The strength of the boilers is even now put to severe tests by the high pressure, and the sensitive parts of the engine cannot endure the high temperatures which might be desirable. The sides of the cylinder, being alternately heated and cooled, communicate to the steam an average temperature which is lower than that of the live steam, and the consequence is a rapid condensation and consequent loss of energy during the period of admission of steam. Efforts have been made to overcome this difficulty by surrounding the cylinder with a steam jacket, or by dividing the expansion into several cylinders, in order to reduce the variations of temperature and the consequent total condensation to a minimum. Thus compound triple and quadruple expansions have been evolved, necessitating more movable parts of machinery and increasing the passive resistance. It has long been the aim of inventors to effect the expansion of steam necessary for economy of fuel by means of less complicated machinery and to avoid the oscillating movement. For the results attained through the investigations of one of them we will give an account below.

De Laval's steam turbine, which forms the subject of our illustration, is in principle similar to the well-known axial jet turbine for water, being so arranged that the steam has acquired the same pressure as the surrounding atmosphere before reaching the turbine wheel, thus converting its entire capacity for work into momentum.

The steam passes between the blades of the turbine at a constant relative velocity and in a clear jet, without any disposition to further change its pressure or specific gravity. The consequence is that the movement of the steam in the turbine is according to the same laws as for water, and the blades of the turbine can, therefore, be constructed in the same manner as if designed for water.

Some idea of the size of the steam turbine may be obtained when we say that the engraving represents, actual size, the wheel of a twenty horse power steam engine which was run at the World's Columbian Exposition, at Chicago, driving a duplex dynamo. This wheel is journaled in a steam-tight casing, in which are located the nozzles supplying steam to the turbine. The blades against which the steam strikes are made thin at the edge to reduce the resistance to the flow of steam. In this turbine steam is expanded to the pressure of the surrounding medium before arriving at the blades. This expansion takes place in the nozzle, and is caused by making the sides of the nozzle divergent. As the steam passes through the nozzle its volume is increased in greater proportion than the cross section of the jet, thus causing an increase in velocity. With an initial pressure of seventy-five pounds, and an expansion to the pressure of one atmosphere, the final velocity of the steam is about two thousand six hundred and twenty-five feet per second. If the expansion is continued to the pressure of one-tenth of an atmosphere, the resulting velocity will be about four thousand six hundred feet per second. It will thus be seen that expansion is carried much farther in this steam turbine than in ordinary steam engines.

The wheel is made of steel, the blades being cut out of the solid material by means of a milling machine. A steel ring is shrunk on the periphery of the wheel, to prevent the steam from passing over the ends of the blades. It also serves to oppose the tendency of the turbine to act as a fan.

With the greatest possible care, it has been found difficult to perfectly balance the wheel. To meet this difficulty the inventor has placed the wheel upon a flexible shaft, so that the turbine when running at a high rate of speed adjusts itself and revolves on its true center of gravity, the center line of the shaft meanwhile describing a surface of revolution. If the shaft were rigid, the vibrations of the turbine wheel would be communicated to its bearings, which would heat and be liable to cutting.

The turbine wheel shaft extends into a gearing box and carries a pinion, which is double, and engages a double cog wheel in the box, the pinion on the turbine shaft being one-tenth the diameter of the driven wheel, so that the speed of the latter is one-tenth of that of the turbine wheel, or two thousand revolutions per minute.

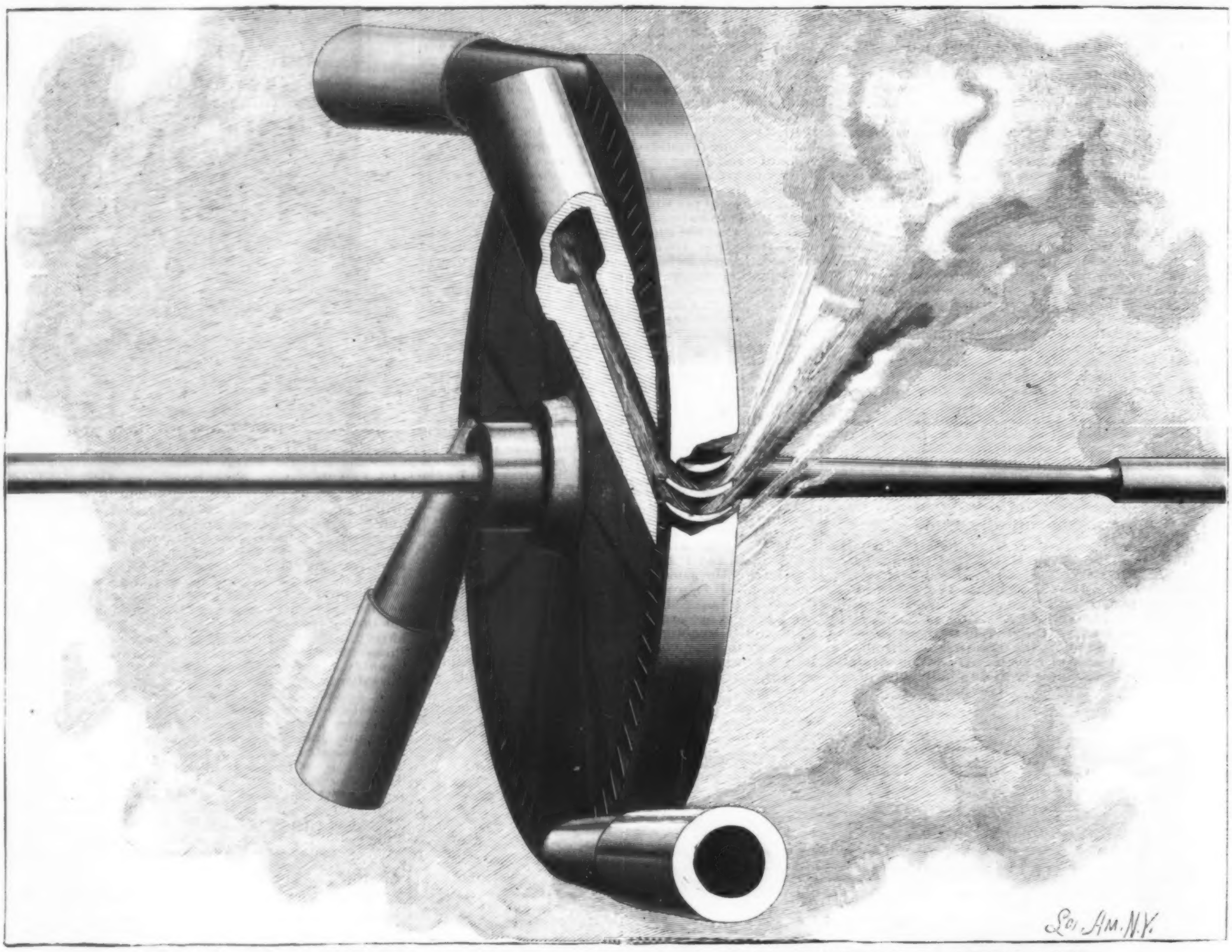
In the gearing box of a larger turbine the speed is reduced from 30,000 revolutions to 3,000 by means of a driver on the turbine shafts which set in motion a cog wheel of ten times its own diameter. These gearings are provided with spiral cogs carefully cut and placed at an angle of about 45°. On account of the high velocity, all tensions caused by the transmission of power are very slight; consequently, the cogs can be quite small, which is one of the conditions for even running of the gearing. The shaft of the larger cog wheel, running at a speed of 3,000 revolutions, is provided at its outer end with a pulley for the further transmission of power.

The turbine box of the large machine contains eight nozzles, of which four can be opened or closed by means of independent valves, according to the power required. The more exact regulation is effected by the governor. The turbine, therefore, can be made to work at the same pressure and degree of expansion even if the effect is varied as 2:1. The nozzles are easily accessible for removal and exchange, if required. The journals and gearing are lubricated from the oil cups on top of the gearing box. This machine is intended to work with condensation. A vacuum is obtained by means of any ordinary condenser. The nozzles are strongly divergent toward the opening, and the entire turbine box made perfectly tight.

The speed of the turbine is controlled by a very sensitive governor on the shaft of the larger gear wheels. The segment weights or wings are movable on knife edges with the least possible friction. When the governor revolves, the weights diverge their inner ends, push a pin forward, this pin in turn causing the cut-off of the steam through the movement of a balanced valve in the steam supply pipe at the top of the turbine. A spiral spring inclosed in the governor keeps the weight in a state of equilibrium at a speed of 3,000 revolutions. It consequently corresponds to the weight of the collar on pendulum governors. The exhaust steam is taken from the center of the turbine box.

This turbine is applied to all uses to which ordinary reciprocating engines are applied, but in the running of dynamos, and in other uses requiring uniform speed, it has proved itself superior to reciprocating engines.

This engine was on exhibition at the Swedish Section, Machinery Hall, World's Columbian Exposition, Chicago; the inventor is Dr. Gustaf de Laval.



DE LAVAL'S STEAM TURBINE DEVELOPING A SPEED OF 20,000 REVOLUTIONS, 20 H. P.—(ACTUAL SIZE.)

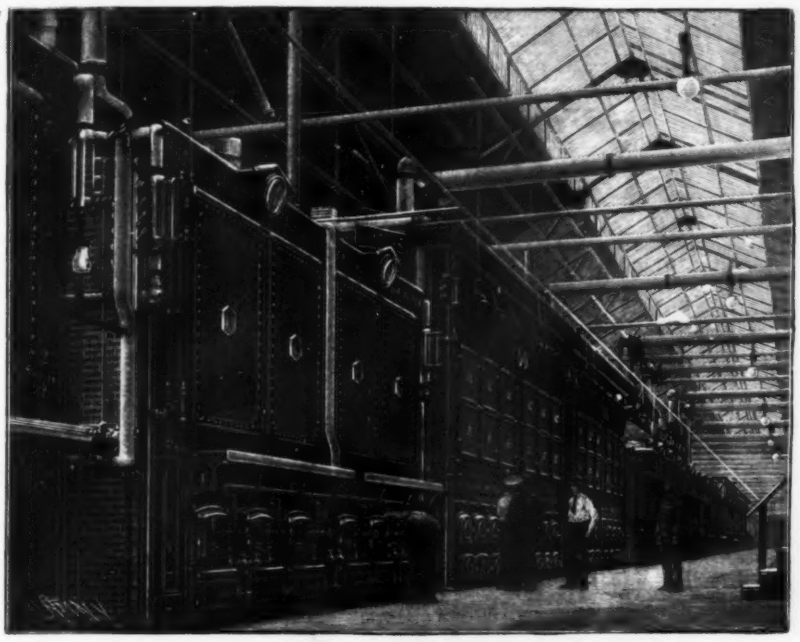
OIL FUEL FOR BOILERS.

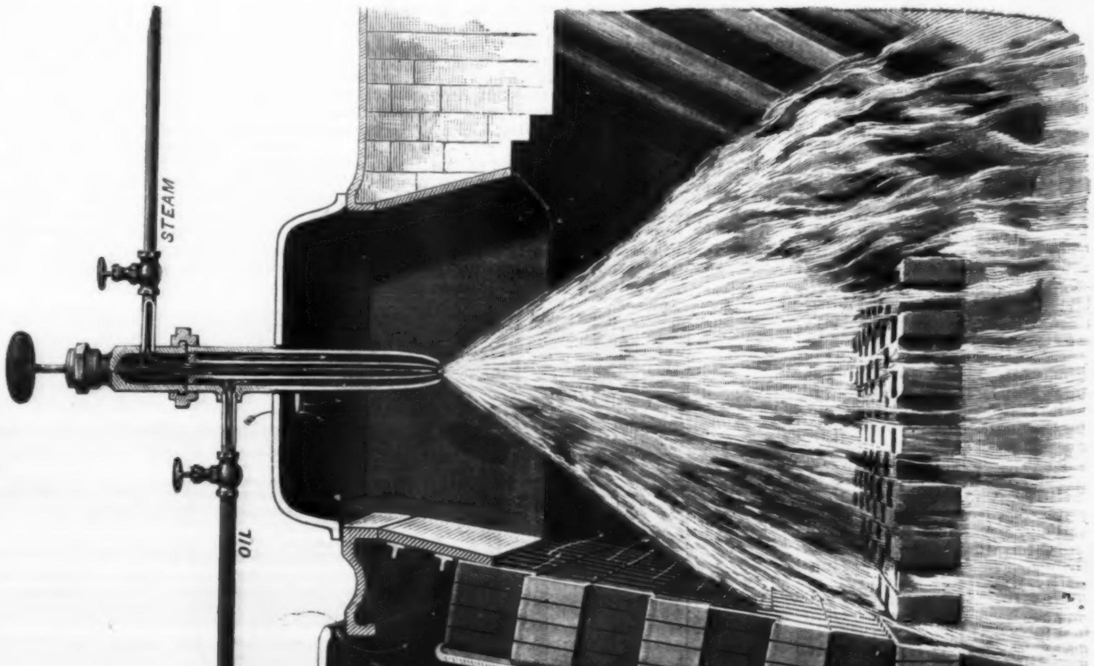
THE motive power for the great Exposition at Chicago was chiefly supplied by a great assemblage of water tube boilers—the greatest in number and operating power ever before collected in one locality. The fuel used is oil. We present in our first engraving a view of a portion of the great boiler house, which, in fact, formed a part of the Palace of Machinery. Our second view shows the type of burner used for the combustion of the oil. The burner consists simply of a tube which enters through the front of the boiler into the combustion chamber. The oil, under a pressure of six pounds to the inch, rises through the pipe marked "oil" into the burner, and is atomized and blown into the combustion chamber in the form of a fine mist, by means of a steam pipe, which passes centrally through the burner and delivers its steam jet at the extreme end of the burner tube, as shown. A great flame of gas is thus produced, with intense heat. The handling of coal and ashes is thus avoided, while economical results of the most satisfactory nature are attained. These oil-burning boilers attract much attention from engineers.

In the great boiler room, or main power plant, there were fifty-two boilers, which generated steam for eighty-three engines. One of the best descriptions of this plant was given in the Chicago *Tribune*, and from it we make the abstracts that follow:

The boilers have a rated horse power of 20 500, but they are capable of developing a horse power greatly in excess of the rating within the limits of economy. They evaporate about 750,000 pounds of water per hour and burn about 50,000 pounds of oil in the same length of time. One pound of oil will evaporate about fifteen pounds of water. Assuming the evaporation to be 750,000 pounds of water an hour, the horse power generated would be 25,000.

The permanent form which the water tube boiler has now assumed consists of a bank of tubes, usually four inches in diameter and from twelve to eighteen feet in length, inclined upward at an angle from the rear, surmounted by a water and steam separating drum from thirty to fifty inches in diameter and about the same length as the tubes. The tubes are expanded into boxes or headers at each end, and these headers are connected with the drum above by circulating tubes or other connections. When in use the tubes, headers and connections are filled and the drum is half filled with water. The water level is carried about the middle of the drum, which, on account of its comparatively large diameter, offers an extensive disengaging surface. This is necessary for the production of dry steam. The furnace is placed under the bank of tubes. The flames circulate around the tubes, being guided up and down by suitable passages so as to cause them to give up as much heat as possible before escaping up the chimney. Connected with the rear end of the tubes and removed from the action of the flames is placed a mud drum for the collection of sediment. The sediment can be readily blown out at suitable intervals.


OIL-FIRED BOILERS AT THE GREAT EXPOSITION.



IMPROVED BOILER OIL BURNERS.

PAPER MILLS IN INDIA.

ACCORDING to a statement published by the government of India, there are nine paper mills—four in the Bombay Presidency, three in Bengal, one at Lucknow and one at Gwalior. Of the nine, three are private concerns (in the Bombay Presidency); the others have an aggregate nominal capital of Rx. 492,200. The fibrous materials used for making paper are chiefly rags, babui and moonj grasses, rice straw, jute and hemp cuttings, and old jute bags and cloth. The quality of the papers made has much improved in recent years, and they have a large and increasing sale. Most of the white and blue foolscap and much of the note paper and envelopes used in the government offices is now obtained from the Indian mills. The total quantity of paper made in 1892 was about 26½ million lb.; ten years ago it was about 7¼ million lb. The number of persons employed is 2,465.

There are a number of small paper works for the manufacture of what is known as country paper, scattered through most provinces, but of these petty industries no account was taken in the return.

BROWN WOOD PULP.

BROWN paper made almost exclusively from wood constitutes an important branch of the paper trade in Germany and Scandinavia. Fry, it appears, was the first to attempt the manufacture of brown paper pulp from wood by simply subjecting it to the action of steam at a high temperature. For this purpose the wood chips were placed in large boilers, and heated with high pressure steam for several hours; the temperature required being 332° Fah., corresponding to a pressure of 90 lb. per square inch above the atmosphere. The action of the steam upon the incrusting substances surrounding the fiber of the wood was not found to be very vigorous. Very little of these substances are, in fact, rendered soluble, but some of them are transformed into useful organic acids (acetic, etc.), which, however, react on the shell of the boiler, causing inordinate wear and tear. In order to obviate this corrosive action of the acids, attempts have been made with greater or less success to steam the wood in the presence of an alkaline body such as lime, which combines with the organic acids, forming compounds that exert no corrosive action on the boiler plate. When this system is carried out, it is obvious that the acids or their compounds are lost; because the wood is steamed in revolving boilers and the insoluble lime salts are intimately mixed with the resulting pulp.

For many years past boilers constructed of wrought iron or steel plate, and covered inside with a coating of thin sheet copper, have been used for the purpose of preparing brown wood pulp. The inside coating of copper forms an acid-resisting lining, upon which the organic acids formed during the steaming process have practically no solvent action. These boilers are of considerable size, being as a general rule about 15 feet long by 6 feet in diameter, their total cubic capacity being about 425 cubic feet. As there is no necessity for them to revolve, they are of the horizontal stationary type.

As the wood is ground after being steamed in these boilers, it must, accordingly, be put into them in pieces to suit the grinding machines. This is done by two workmen, one of whom packs the pieces of wood in layers within the boiler, while the other passes them to him through one of the two manholes placed at each end. Steam of about six atmospheres (90 lb.) is then admitted through a suitable valve, and the pressure, which is recorded by a steam gauge, maintained for 8 or 18 hours, as the necessities of the case may be, or until the wood has been rendered soft and of a dark brown color. The water condensed inside the boiler is allowed to flow away through a tap fixed at the bottom. The acid and oil products distilled from the wood are contained in this condensed water, and are usually collected together in a reservoir. The oil of turpentine, as it is commonly called, floats on the surface and is separated from the water beneath by means of a ladle. It is very inflammable, and, because of its value, is sold.

When the wood has been sufficiently steamed, the pressure is blown off and the boiler filled and emptied

three times with cold water, the object in view being twofold, viz., first, to cool the wood, so that the workmen can easily remove it; and second, to wash it free from impurities, thus making it more suitable for the grinding machines. The boiler is then emptied by manual labor, the pieces being passed out through the manholes.

The acid-resisting lining consists of sheets of copper ⅛ of an inch to ¼ in thickness. These are carefully laid flat over the iron surface and riveted to it with small copper rivets. The manholes are strengthened with an iron ring, and are also carefully covered with sheet copper. The edges of the copper sheets are lapped and soldered. In each ring of plates forming the boiler small holes are bored, which pierce the iron shell, but not the copper lining. The outer part of these holes is threaded, so that a small pipe or cock may be attached to the boiler. These taps are used for ascertaining whether the copper lining is tight. A little water is forced by means of a small pump into the space between the boiler shell and the copper lining, so that the workman can localize any leak by carefully examining the inside. If at any time a leak in the lining occurs, the steam or water is observed to issue from these taps, in which case the lining is at once repaired.—*Chem. Tr. Jour.*

THE CONFECTIONERY AND BAKERY EXHIBITION.

An exhibition of confectioners' and bakers' devices was lately held in the Agricultural Hall, Islington, London. The *Engineer* describes some of the improved machinery as follows:

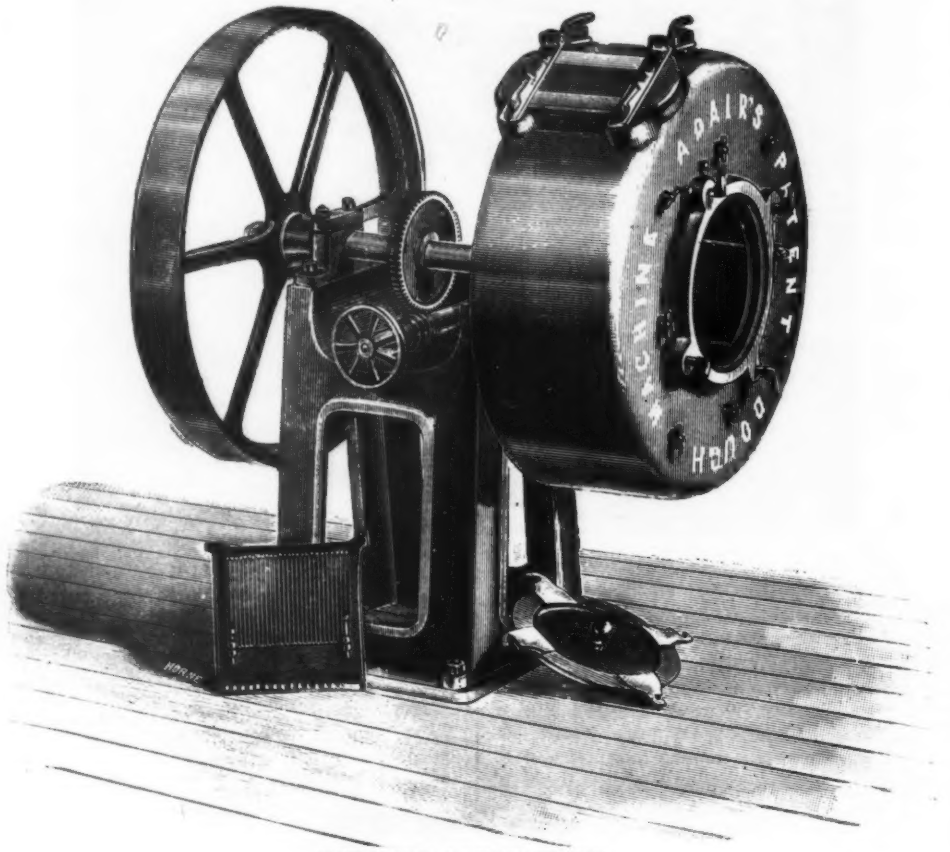
Among the machines are those exhibited by Messrs. Werner, Pfleiderer, and Perkins, including dough mixing and kneading machines, which vary in size from machines for hand power to machines taking eight horse power, and capable of turning out twenty five tons of dough per day; machines for cutting up dough into any number of pieces of the same size, and bakers' and confectioners' ovens, the latter being on the Perkins well-known system of construction, and heating with high-pressure steam and water pipes.

DOUGH DIVIDER.

A machine for cutting up a mass of dough is illustrated by the accompanying engraving. The dough is placed on the small table shown.

The central circular part of the table, which is shown divided into segments, descends several inches, leaving a flat circular chamber of two or three inches in depth. Into this the weighed lump of dough is placed, and the hinged cover brought down and fixed by a catch. The segmental bottom of the chamber is then raised by one of the levers shown, and the dough becomes a cake filling the chamber. The second lever is then used, and it raises a series of cutter knives which fill the slots between the segments, forming the bottom of the chamber. This set of knives rises to the top cover and then retires. The cake of dough is thus cut up into a number of pieces, not all of the same shape, but all of the same weight. The bottom of the chamber is then raised to the position shown.

The novelty of the exhibition in dough-making machines is that exhibited by the Adair Syndicate, as made under Adair's patent. In this machine all mechanical mixing arms are dispensed with. As shown in the engraving herewith, the machine consists simply of a drum-shaped cast iron receiver fixed on a horizontal shaft, which is rotated slowly in bearings on a vertical frame. On the opposite end of the shaft is a fly wheel, which also acts as a driving pulley. The shaft does not pass through the receiver, but is fixed in a large boss in the back of it; the shaft is hollow, and, by means of a stuffing box in the pulley end, water or steam can be passed into the receiver as required. The interior of the receiver is simply an empty drum, with the exception of eight small rods or wires, which are stretched across from side to side and held by the thumb screws seen on the front side of the engraving. The slow rotation of the drum mixes and kneads the dough, which, as it forms into a mass, is continually cut up by its own weight as it falls on the eight wires, and complete incorporation of the materials and the formation of dough is, it is stated, effected in from one and one-half to two minutes.

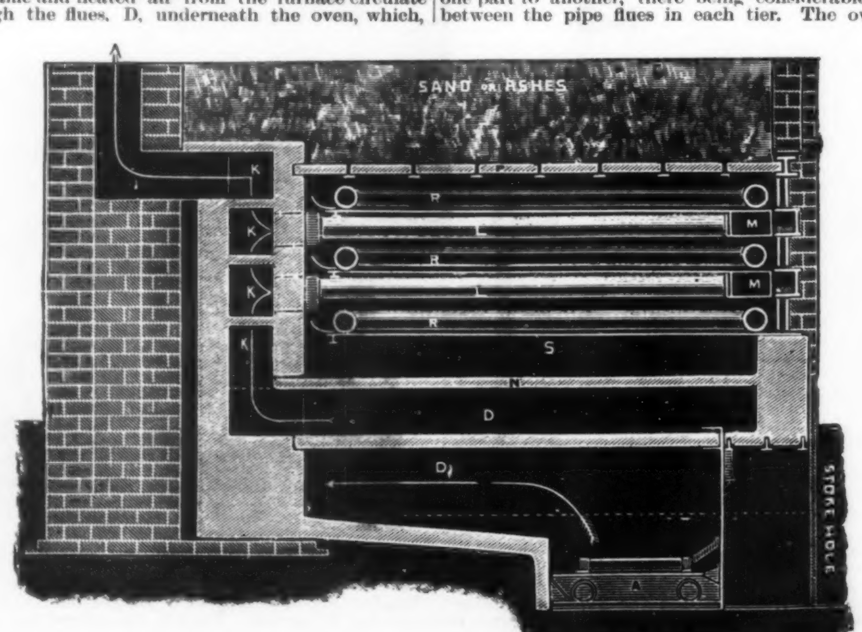


IMPROVED DOUGH MIXER.

There are two doors in the receiver, one in the circumference for charging and discharging, and one in the front for cleaning purposes, etc. When charging, the receiver is turned round by means of a worm-geared wheel fixed in the center of the shaft until the door is at the top and immediately under the shoot, from which the flour is let into the receiver. The proper amount of water having been previously run into the machine, the door is closed, and the receiver set in motion at a speed of about thirty revolutions per minute. In discharging, the receiver is stopped with the door at the bottom, which, being opened, the dough falls into the troughs placed to receive it. The receiver will hold two sacks of flour.

A sponge blender is a separate part of the machine, and consists of a gun-metal frame, nickel plated, having fine piano wire stretched across the opening, and a series of small blades dispersed along the end. This blender is passed through the door in the circumference of the receiver, and dropped into two slots, one on either side of the door, and is retained in its place by the door being closed on it. It stands in the receiver about two feet, so that as the receiver revolves the sponge is divided first by the small blades, and afterward passed through the wires until it becomes a creamy solution. It will be noted that this is, in fact, a sponge blender, and not a sponge breaker, which, to all practical bakers, is an important distinction. The operation of blending the sponge occupies about two minutes.

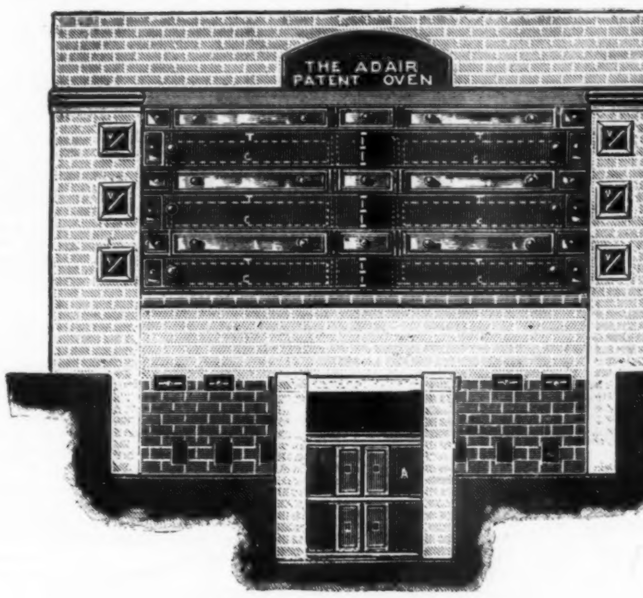
Mr. Adair is also the inventor of the baker's oven illustrated by the accompanying engravings. This oven is a chamber built in brickwork, heated by flues underneath and at the back and front, and also by two tiers of iron pipe flues passing through the oven. The flame and heated air from the furnace circulate through the flues, D, underneath the oven, which, being built in brickwork, serve to equalize the heat, absorbing heat when the fire is very good, and giving it out again as the fire becomes low. This equalizing effect is also aided by means of suitably arranged dampers, by which the direction of the hot air through the flues may be reversed or checked at any point. After circulating through the heat-storing chambers, the hot air rises into brick flues, K, running across the back end of the oven. These are connected with the two tiers of pipe flues in such a manner that the hot air first circulates through the bottom tier of pipes, R, passing to the front of oven through six, and returning again to the back of the oven through the other six—there being twelve pipe flues in each tier, opening into a hollow box girder running across the front of oven corresponding with the brick flues across the back. The hot air then ascends to the upper tier of pipes, and goes through the same course, thence to the chimney. By a suitable and simple arrangement of dampers the distribution of heat is under perfect control. For instance, the direction of the current through the pipe flues may be reversed, causing the hot air to pass first through the six pipes on the cooler side of the oven, and return on the hotter side; or either or both tiers may be shut quite off, in this case allowing the heated air to pass directly from the underneath flues to the chimney. The expansion of the pipe flues is provided for in a sufficient manner, at the same time insuring an absolutely sealed joint, so that at no part of their course can the heated air from the furnace enter the oven chamber, or the steam from the bread escape into the flues. There are no floors dividing the oven into absolute decks. The whole of the interior of the oven is perfectly free for the circulation of heated air from one part to another, there being considerable space between the pipe flues in each tier. The oven has



IMPROVED BAKERS' OVEN.

one furnace, which is fitted with wheels and placed upon a track, so that it can be drawn out away from the oven for repairs; the oven still being available for baking, having a large amount of stored-up heat in the underneath flues. There are six trays, S, in the oven, the two bottom ones being run in on rails supported immediately over the bottom of the oven, and underneath the lower tier of pipe flues. The two middle trays are run in on rails supported immediately over the bottom tier of pipes and underneath the upper tier. The two top trays are run in on rails supported immediately over the upper tier of pipes and underneath the oven roof. The size of trays is 10 ft. by 4 ft. The trays, which are now generally used in all the modern ovens, abolish the use of the peel, and dispense with the skilled services of the runner—setter—and drawer. A boy can push them into the oven loaded and draw them out again. The six trays when full will hold about 1,000 half-quartern loaves. These trays are constructed of strong wire lattice, over which is placed light asbestos cloth. It is stated that asbestos is peculiarly fitted as a bed for baking upon, as it conducts the heat slowly, after the manner of a tile, and, being porous, the steam can escape through it; consequently the hard, flinty-crusted loaf that is formed by baking upon iron is avoided.

A steam-heated oven was exhibited by Messrs. Collins & Co., Bristol, the oven exhibited being capable of baking 100 sacks of flour in loaves, on a consumption of one ton of coke, the working being assumed continuous, and the quantity of water used in making the dough about 15 gallons per sack of flour. It will be seen that if this be so, about 60 per cent. of the fuel consumed would be required to evaporate the water from the dough, leaving, say, 13 per cent. of moisture in the bread.



IMPROVED BAKERS' OVEN.

UTILIZATION OF OLD RUBBER.

By R. HENRIQUES.

THE importance of the American trade in recovered rubber may be gathered from the fact that about twenty-five million pounds of old overshoes are collected and worked up annually. Two processes of recovery are in use. According to the first, the rubber is finely ground, sifted to separate it from fragments of textile material, steamed under a pressure of six atmospheres, and rolled into plates. In the second method the raw material is divided into pieces about 1 sq. cm. in size by passage between channeled rollers, boiled with dilute sulphuric acid to remove textile materials, washed with water alkaline with soda, finely ground and steamed in the same manner as in the former case. Apparently the steaming process partly devulcanizes the rubber, as otherwise it could scarcely be moulded. This view is upheld by the observation that recovered rubber only contains a little vulcanizing sulphur, but a good deal of sulphuric acid (presumably as sulphates).

Analyses are given of three samples of rubber put upon the market by the Rubber Reclaiming Company, New York, in the form of black rolled plates 3-5 mm. in thickness, possessed of no great elasticity, and, in fact, resembling ordinary black rubber goods of common quality. The material is loaded with mineral matter, as is common for goods of this class, the following figures being obtained:

	A.	B.	C.
Sp gr.	1·66	1·59	1·65
PbO	12·87	14·02	12·23
$CaSO_4$	22·13	21·59	21·43
$CaCO_3$	18·00	10·91	17·86
$Fe_2O_3+Al_2O_3$	0·80	2·74	1·10
SiO_2	1·75	0·40	1·60
H_2O	0·52	0·55	0·62
Vulcanizing S	0·71	2·03	1·40

Fatty oils and rubber surrogates were looked for by the author's new methods (*Analyst*, xviii., 223), but were absent Asphalt and lampblack were recognized qualitatively, but no exact process for their estimation yet exists.

But little information has been published as to the composition of rubber used for such purposes as the manufacture of overshoes. One recipe which has appeared gives 18 parts of Para rubber, 11 of litharge, 40 of chalk, 3 of asphalt, ½ of lampblack, and 11½ of sulphur. The product would be brittle, however, on account of the small percentage of rubber and the large proportion of sulphur. In other respects it will be seen to be similar to the mixtures sold as recovered rubber, the composition of which is given above. In this recovered rubber it is a matter of much difficulty to determine with precision the content of true rubber, but it may be taken as in no case higher than 35 to 40 per cent.—*B. B., Chem. Zeit.; The Analyst.*

SUGAR MAKING IN HAWAII.*

IMPROVEMENTS in machinery and methods of working, coupled with the interchange of ideas, which is part of our modern civilization, tend to make manufacturing industries somewhat uniform, no matter in what part of the world they are carried on. There are, however, two factors which tend to make sugar making in Hawaii different from that industry in Louisiana. These are the greater purity of cane juice and the requirements of our market.

Beginning with the juice, which is extracted by mills with or without maceration, as in Louisiana, we find that it shows an average coefficient of purity approaching 90. In fact, 90 is generally taken as the average purity, but I think it is a little too high. During the season of 1892 I found the average of the five mills in this district to be 88. Of course, juices with a purity of 90 are quite common, and occasionally as high as 93 or 94; but the working of juice of as high apparent purity as this indicates, I think, the presence of some other dextro-rotary body than sucrose. Below are analyses of juices of maximum, minimum, and average points:

	Max.	Min.	Average.
Density brix	19·60	19·15	19·62
Sucrose	18·60	15·90	17·38
Glucose	0·14	0·39	0·32
Glucose ratio	0·75	2·45	1·84
Solids not sugar	0·86	2·86	1·92
Coefficient of purity	94·8	83·0	88·6

Of course, the density is not always as high as in these samples. Here is the analysis of a sample of lowest density during season of 1892:

Density brix	16·51
Sucrose	15·30
Glucose	0·35
Coefficient of purity	92·6

As will be noticed, the glucose content of these is much below that common in Louisiana.

The analysis below gives the highest glucose content I have found here:

Density brix	20·71
Sucrose	17·61
Glucose	0·74
Glucose ratio	4·20
Solids not sugar	2·36
Coefficient of purity	85·0

This was juice from cane which had been left in the hot sun five days after being cut. Juice from the same cane ground as soon as cut gave:

Density brix	20·12
Sucrose	17·42
Glucose	0·33
Glucose ratio	1·89
Solids not sugar	2·37
Coefficient of purity	86·5

This leads me to mention the fact that mature cane deteriorates very rapidly after being cut, and much more care must be exercised here in cutting just enough and no more than the mill needs than is necessary in Louisiana, where the green (immature) cane remains the same for some days after being cut.

Clarification of the juice is generally done in iron clarifiers of five hundred gallons capacity, heated with copper coils or pipes. Neutrality is the point aimed at in liming; the appearance of the juice as viewed in a test tube and an occasional use of litmus paper being the only tests made. Two methods of clarification are practiced, "cracking" and skimming. With pure juices there is, I think, little difference in these methods, but with juice from green cane skimming and more prolonged heating give, I think, better results.

The skimmings and settlings are run through filter presses. The juice so obtained is sometimes run back through the clarifiers.

* From the *Louisiana Planter*.

The treatment of the juice after it leaves the clarifiers and before it enters the multiple effect varies greatly. Some use cleaning pans in which the juice is reheated and skimmed; others precipitators or settling tanks; others filter bags, such as are used in refineries, and some a combination of two or all three of these.

The evaporators are double or triple effects of the standard type, with vertical tubes, in which the juice is evaporated to a density varying from 28 to 33 Baumé.

Below are two analyses of sirup:

	No. 1.	No. 2.
Density brix	57·6	58·7
Sucrose	53·0	56·6
Glucose	1·11	1·41
Glucose ratio	2·09	2·48
Solids, not sugar	3·49	0·69
Coefficient of purity	92·0	96·4

With such high coefficient of purity it is possible to work sirup in the vacuum pan of a density as great as 35 Baumé, so that the multiple effects are generally allowed to evaporate the juice to as great a density as they are able, and keep up with the work, leaving less evaporation for the vacuum pan. As the multiple effects rarely use other than exhaust steam, sugar houses here have an advantage in economy of steam in this particular over those in Louisiana.

Vacuum pans in use here are often much smaller in comparison with the capacity of the sugar house than is the case in Louisiana. For example, a house having a capacity of twenty-six tons of sugar per day may have two pans of four tons capacity each.

The use of steam in the vacuum pans varies—some use live steam alone, others live and exhaust, and others exhaust with enough live steam to bring the back pressure up to five or six pounds. The styles of vacuum pumps also vary greatly; both wet and dry systems are used.

In the working of the vacuum pan a medium sized grain and a masse cuit as stiff as the outlet of the pan will allow are the points aimed at.

First sugars polarize about 98 without washing in the centrifugals. By using one quart of water to each machine I have seen first sugar made polarizing 99·8.

Second sugars are nearly always grained in the pan—that is, the molasses from first masse cuite is worked in the same way as sirup. The molasses which is taken into the pan after grain is formed is generally diluted with water to 35 deg. Baume.

An analysis of first molasses taken at random gives:

Total solids	77·20
Sucrose	63·59
Glucose	4·20
Coefficient of purity	83·3

Molasses from second masse cuite is boiled to string and run into wagons or coolers; the resulting third sugar is purged after standing about ten days. Hot rooms are not known here; the wagons or coolers are allowed to cool and remain at the temperature of the sugar house, generally below 80 F.

The molasses from third sugars is generally boiled for fourth sugar and allowed to stand until the end of the grinding season.

Third sugar will polarize about 88 deg. and fourth 84 or 85.

Fourth molasses will average:

Total solids	80
Sucrose	35
Glucose	18

This molasses is for the most part a waste product; some is fed to stock and some used for fertilizing purposes, but the greater part of it goes into the Pacific ocean. Fifteen gallons of molasses per ton of sugar is the lowest estimate that can be made.

Weston centrifugals are in most general use, and the old style with belts overhead often play havoc with the hands or arms of some unlucky Jap. First and second sugars are generally purged as soon as they come from the vacuum pan.

With good work the percentage of first sugar should not be less than 71 or 72 per cent. of total sugar, and the first, second and (third and fourth) should stand in proportion of 72, 21, 7.

The sugar maker, or sugar boiler as he is called here, is responsible for the juice after it leaves the rollers, and his clarifier, multiple effect and vacuum pan men are either Japs or Chinamen.

The fact that a Jap or a Chinaman of ordinary intelligence can, after a training of two or three months, take charge of a vacuum pan and do the work well, will, I fear, be unpleasant news to those sugar makers of Louisiana and Cuba who base their reputation on the mystery with which they attempt to shroud the vacuum pan.

I have referred to the market for our sugar as one of the factors influencing sugar making here. I should more properly have said the absence of a market. The Pacific coast of the United States seems the only place for our market, and if we send it there we are forced to sell to the refiners.

In consequence, we make a refining sugar which is sold on polarization; and appearance and color, which count for so much in Louisiana, here do not count at all.

Up to 1893 Hawaiian sugar sold under a contract which called for price of Cuban 96 degrees in New York, less certain deductions for freight, with an allowance of ⅛ cent for every degree above 96 degrees, and a deduction of ¼ cent for every degree below. Under this contract the great increase in price for increased polarization more than compensated for loss in weight, and the practice of melting second and third sugars and making one grade only, polarizing about 97·5 degrees, was common. Now, however, the planters are under a five years' contract which allows only $\frac{1}{32}$ cent for every degree above 96 degrees, and a deduction of $\frac{1}{16}$ cent for every degree below, so that there is no longer the inducement to make sugar of high polarization at the expense of weight. With the exception of one mill, which is not under contract with the refiners, sulphur is not used here, and as long as we make sugar for refining purposes only, I cannot see that its use would be any advantage to us.

Sugar houses here are generally kept running from 6 A.M. to 5 P.M., unless there is some reason for working

off the crop in a shorter time, when the grinding may be continued until 8 or 9 P.M.

On many plantations with a small mill and large crop work might advantageously be carried on day and night, as mature cane generally begins to deteriorate standing in the field after July.

Of the five mills in this district bagasse furnishes the only fuel, and often one-fourth, at least, is not consumed; but the question of bagasse burning deserves separate consideration, so I will not deal with it here.

These remarks on sugar making are intended to apply only to the sugar houses on this island (Hawaii). Where irrigation is practicable, the quality of the juice is, I think, generally of poorer quality than here, where we depend on the rainfall entirely.

EDMUND C. SHOREY,
Chemist Kohala Sugar Co.

Kohala, Hawaii, September, 1893.

"AMEN" MUMMY COFFINS IN THE BRITISH MUSEUM.

THE Khedive has presented the British Museum with four mummy coffins of great interest. Egypt has given us many surprises, but none more striking than the discoveries made in 1887 and 1891. In the former year the royal mummies, including those of Thothmes III., the conqueror of Asia, and Rameses II., were discovered. In 1891 the still more wonderful find was made of the mummies of the priests and priestesses of the order of Amen. Scholars at once associated these two results of research with each other. The mummies were found in vast excavated hiding places, showing that there must have been a reason for the concealment. Round these coffins one of the most remarkable chapters of the religious and secular history of the world centers, the order of Amen having been probably the most powerful and perfectly organized ancient sacerdotal order. The discovery of 1891 was made by M. Grebaut in the immediate neighborhood of Deir-el-Bahari, where he found a well giving access to an immense tomb, in which were 163 coffins of members of the confraternity of Amen. There were also a number of *ushabti* figures and statues of Isis and Nephtys, the latter being hollow and containing papyrus rolls. All these objects were removed to the museum at Ghizeh, where the larger portion are now on exhibition. But the Khedive and the museum authorities decided to present the surplus coffins to the European powers which had shown such great interest in Egyptian exploration. Accordingly a few months ago a raffle was held at Ghizeh, and four of the coffins and some other objects fell to the lot of the British Museum. The coffin of a priestess in the museum is that of Tenthansf, and is very large and "double," presenting a fine specimen of Egyptian work, probably of the twenty-second dynasty. The paintings which decorate it are taken chiefly from the "Book of the Dead." Another coffin is that of a priest whose name is unknown, but who seems to have been an incense burner in the temple. Like that of the priestess, it is richly decorated. The coffin is probably of the time of the twenty-first or twenty-second dynasty. Along with the objects presented to the museum are a pair of sepulchral boxes belonging to a priestess Huit. These probably contained toilet and other necessaries for the deceased, and are adorned with mythological scenes. These coffins and objects are a most valuable contribution to the collection of the British Museum; it would, indeed, be matter of regret if this collection did not contain some specimens of the work of this great order of Amen.

MICROSCOPICAL NOTES.

Carmalum.—This is the name given to the most recent carmine stain for histological purposes. It has been devised by Dr. Paul Mayer, and is very easily prepared. One gramme of carminic acid is placed in a suitable vessel, together with ten grammes of ammonia alum and 200 c. c. of distilled water. The mixture is then heated nearly to boiling point, until solution is effected, and, after cooling, carefully decanted or filtered, when it is ready for use. The addition of a small crystal of thymol keeps the solution free from organic growths. It is a dark red liquid of great staining power and, like picrocarmine, will stain objects satisfactorily that have been fixed in osmic acid. It is said to tinge the protoplasm slightly as well as the nucleus (*Nat. Science*, iii., 113).

Aniline Stains.—A general recipe for these stains, recommended by Hermann and said to serve equally well for safranine, gentian violet, eosine, fuchsine, fuchsine S, dahlia, and orange G, is as follows: Staining substance (dry), 1 gramme; absolute alcohol, 10 c. c.; aniline water, 90 c. c. As thus prepared anilines are said to stain very intensely and sharply. Washing out should be done in absolute alcohol, though with safranine acid alcohol may be used. The solutions require to be used fresh, as they do not keep very long (*Nat. Science*, iii., 121).

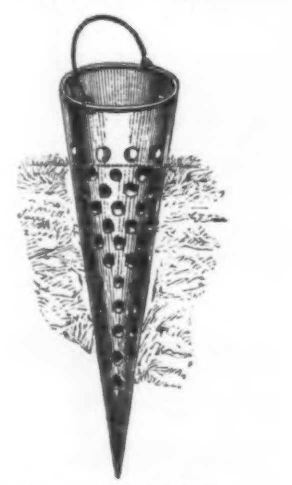
Staining Connective Tissue.—Pharmacists who are called upon by medical practitioners and others to prepare animal tissues for microscopic examination may find Beneke's process for staining connective tissue a useful one. It is a modification of Weigert's method for staining fibrin, and by means of it Beneke claims that the connective tissues of the most diverse organs can be consistently stained. Portions of tissue that has been fixed in alcohol, having been embedded in paraffin and cut, the sections are attached to slides in the usual way and stained for ten to twenty minutes with aniline gentian violet (aniline oil, 10 parts, well shaken with water, 100 parts, then filtered, and concentrated alcoholic gentian violet solution, 5 to 10 parts, added to the filtrate). Afterward treat for one minute with lugol solution of a port wine tint, dry with filter paper, and decolorize with aniline xylol (aniline oil, 2 parts, xylol, 3 parts). Decolorization having been stopped at the right point, which must be judged from experience, mount the sections in xylol balsam. The fibers of the connective tissue should appear stained various shades of violet (*Centralb. f. allgem. Path.*, through *B. M. J. Epit.*, p. 40).

Bleaching Sections.—An ingenious method of bleaching histological sections before staining is described by E. A. Minchin, and consists in placing the sections in a bottle of 80 per cent. alcohol, having a layer of potassium chlorate crystals at the bottom. A few drops of concentrated hydrochloric acid are then cautiously added and the bottle is subjected to a gentle heat. The chlorine evolved is said to bleach sections in about an hour (*Nat. Science*, iii., 121).

Fixing Microscopic Objects on Slides.—To fix minute objects in a definite position on a glass slide J. Tempere applies to the particular part of the surface of the latter, after warming (at about 40° to 50°), to remove all traces of moisture, a drop of a medium prepared by dissolving on a water bath 15 grammes of white lac in 100 grammes of absolute alcohol, and decanting off the clear liquid after standing awhile. As the alcohol evaporates from the warmed surface of the glass a hard transparent coating is left. This may be slightly softened at any time by means of a drop of oil of lavender, and after arranging the objects the heat of a spirit lamp will cause the oil to evaporate, leaving them firmly attached. Objects may be mounted on cover glasses in a similar way. A resinous mounting medium may then be employed in the usual manner. If glycerin or glycerin jelly be the mounting medium used, collodion diluted with two or three times its volume of oil of lavender may be found preferable as the fixing agent. The sections, etc., should be placed in position before the preparation dries and the oil evaporated at a temperature of about 50° (*Micrographe préparateur*, i., 81).

A WIREWORM TRAP.

THE wireworm is one of the most troublesome pests of the garden, and of all the nostrums recommended



WIREWORM TRAP.

for its destruction none is really effectual. Gas lime, if used sufficiently strong to kill the wireworm, kills the plants. The only effectual way of dealing with them is to catch them. Messrs. Osman & Co., 132 and 134 Commercial Road, E., have introduced a most effectual trap in the form of a perforated cone, made of sheet iron, into which a carrot is inserted, and the cone thrust into the ground, as in the accompanying illustration. I have tried a dozen of the traps during the past six weeks, and find that they quickly clear the ground of this enemy of carnations. I am putting down two dozen more on some new ground I have broken up for carnations. I saw the traps exhibited at the Agricultural Hall flower show recently, and bought a dozen for trial; and I believe I am doing a public benefit in drawing attention to this little known and useful article.—*J. Douglas, in the Gardeners' Chronicle.*

TOBACCO SMOKE FLOATED UPON CARBONIC ACID.

COAL, on burning incompletely in the air, yields oxide of carbon, a gas which is a very violent poison,

TOBACCO SMOKE FLOATED UPON CARBONIC ACID.

and so much the more dangerous in that there is no odor to announce its presence; when, on the contrary, the combustion is complete, the gas produced is carbonic acid. Although less poisonous than oxide of carbon, it announces its presence by a slight pricking sensation in the nose and mouth; and, although it now and then causes an accident, it must not be forgotten that it is what gives seltzer water its so agreeable, refreshing and sharpish taste in summer, and that makes beer and champagne foam.

The preparation of carbonic acid is very simple. Let us put a few pieces of chalk and some kind of acid (vinegar, for example) into a bottle, and close the latter with a cork provided with a tube to lead the disengaged gas to a receiver.

It may also be prepared by pouring water upon a mixture of equal weights of powdered bicarbonate of soda and tartaric acid. This process is employed in families for the preparation of artificial seltzer water.

Upon uncorking a bottle of carbonic water and quickly closing it with a cork provided with a bent tube, a small quantity of carbonic acid gas, quite sufficient for a few experiments, may easily be procured.

By means of one of the producing apparatus mentioned above, let us introduce some carbonic acid into a large jar, but in such a way as not to fill the latter completely. Although the level of the gas cannot be perceived, since it is as colorless as air, it may be recognized approximately by means of a candle attached to a wire and lowered slowly until it is extinguished. This is the point of separation of the acid and air. Let us then blow the smoke of a cigarette gently upon the surface of the gas, and we shall see it form waves and float, so to speak, upon the carbonic acid, and, upon shaking the jar, we shall plainly see its level oscillate like that of a liquid, thanks to the smoke blown upon it. In an instant we shall witness a curious phenomenon: the gas will diffuse itself in very visible wreaths upon a black ground, each of which terminates in a toadstool-like appendage. These vortices will descend slowly to the bottom of the jar. —*L'Illustration.*

THE MAKING OF MOUNTAIN CHAINS.

By H. G. WELLS, B.Sc.

WITHIN the past decade speculation upon the process of mountain formation has attracted a considerable amount of attention from geologists. With increased stratigraphical knowledge it has been possible to trace the successive stages in the life of an elevated region with increased certainty, and a great and growing quantity of collateral information has been collected upon volcanic phenomena, earthquakes, the microscopic structure of rocks and the behavior of viscous bodies under pressure.

The history of every mountain range seems to resolve itself into the story of an incessant struggle between hypogene and solar energy. From the moment the land emerges from the sea the forces of denudation begin to act upon it; as the upheaving powers win for a time and the land gradients increase, erosive action becomes more and more efficient, the wedges of the frost come to aid the wear of the rain as the snow line is approached, and at last the Titanic forces of elevation, the strength of the caryatid giant, old Seismos, becomes exhausted and the record of his efforts is slowly erased by the at last triumphant forces of the air. This, in brief, is the life history of every mountain chain, the common plot of all the stories at which we are now to glance.

Somewhere in Swedenborg's writings there is an account of the examination by angels of one of the risen dead. They did not ask the man questions or subject him to cross-examination. They simply took his body, and methodically from that infallible document read out to him all the things he had done. If I remember rightly, they began by "unrolling his fingers." Whatever act his fingers had performed had left its record in their structure, and whatever thought had passed through his brain had made its infinitesimal difference there. This is precisely the way the scientific man hopes at last to build up the history of the past. Every hill, every pebble, every microscopic patch in a weathered feldspar, every cleavage crack in a needle of hornblende, rightly interpreted, bears its witness to the cosmic forces that have been at work upon them; and at present we must read the story of the mountains in this way, so far as our light permits We may best begin by remarking upon a few of the most significant features of existing mountain masses.

Perhaps in the order of their importance one should first notice the fact that almost all our great mountain chains have, high up upon their flanks, rocks of comparatively recent origin, and that we often find great thicknesses of such rocks. The very summit of Mont Blanc, for instance, was once surmounted by Jurassic rocks. Cretaceous rocks crown the Rocky Mountains, and tertiary masses lie at great elevations upon their sides. Nummulitic limestone, a foraminiferal rock of early tertiary age, is found at heights of nineteen and twenty thousand feet on the Himalayas, and still younger pliocene formations lie high on their slopes. The elevated *molasse* of the Alps is a middle tertiary rock Not one of the really great mountain chains of the globe appears to have been elevated, or, indeed, above water during the mesozoic period. At that time each was an area of deposition, and further, of subsidence, as the accumulated thickness of mesozoic strata, witnesses. So that we must figure for the beginning of our story a sea, near land indeed, or strata would not accumulate, and with a sinking bottom, or its silting up must have occurred in the place of continuous deposition.

Of course, when we state that the early tertiary and upper mesozoic rocks are *recent*, the non-geological reader must understand we mean recent relatively to the length of geological periods. The date of accumulation of these sediments is certainly a matter of hundreds of thousands if not of millions of years.

Mr. Mellard Reade has insisted particularly upon the importance of this fact of the comparatively modern sedimentary structure of mountain masses. He has, indeed, propounded a theory of the origin of mountain elevation largely based upon this. As everybody knows, there is within the earth an enormous store of heat; for instance, near the surface for every fifty feet or so we go down the temperature rises 1°. The temperature of the surface—disregarding solar radiation —is the net result of two processes; heat must be continually arriving from the hotter interior by conduction, and heat must be continually escaping by radiation into space.

Mr. Reade asks us to consider the result of a continually increasing thickness of strata over any part of the earth's surface. It will act, just as a blanket

does, by preventing the escape of heat. The rocks below will in time grow warmer, since they are no longer superficial, and the growing accumulation of strata will also be heated. The whole mass will expand horizontally and vertically, the movement of subsidence will finally cease, and at last, as a consequence of the lateral strain, the horizontal strata will bulge and be ridged upward into the form of mountain masses.

More striking, perhaps, than the recent age of their constituent strata, and almost equally significant, is the folding that mountainous regions have undergone. We cannot do better than call attention here to the accompanying figure of that classical example, Mont Blanc. The strata, the reader will see here, have been folded and folded again, and their ridges have been denuded. If one takes the edges of a sufficiently flexible book and approximates the ends, one may imitate these foldings roughly, but they may be imitated still better by compressing layers of cloth laterally beneath a weight.

Now, unless all the elementary presumptions of geology are wrong, these folded strata must originally have been deposited horizontally. Since their deposition, therefore, their extremes have been brought nearer together. This puckering points unmistakably to a squeezing in from the sides. It has been calculated, in the case of the Alps, that points on either side of this mountain mass have been brought closer to one another by as much as seventy-two miles. In the case of the Appalachian Mountains the estimate is eighty-eight miles. We seem to have here, then, the clear record of the successive stages in such a process as is indicated in a simplified fashion by our Fig. 2 (A, B, C, D), in which A, B and C represent phases in a steady lateral compression and D repeats C, with some allowance for the action of sub-aerial denudation.

It is upon this aspect of mountain structure that Prof. Lapworth laid particular stress in his memorable address to the Geological Section of the British Association. He insisted upon the horizontal pressure and upon the strata *giving* to this strain at their weakest points, bulging up into ridges and furrows, and with further compression folding over, so that we get at last "over-folds" (Fig. 1), with an upthrust or *arch limb*, a *middle portion*, and a down thrust or *trough limb*. The middle portion must especially be under great pressure, and it may undergo crushing, or the fold may rupture and the arch slide forward over the fault to form a reversed fault or over-fault or thrust plane as in Fig. 5. The final result of this folding will be to strengthen the crust at the original weak point by more than doubling its thickness, and adjacent portions of the strata will then begin to pucker. So that in the flanks of the original fold fresh folding will arise until we get either a fan-like series (as in Mont Blanc) or a one-sided arrangement (Fig. 3) such as is displayed in the Appalachian and Jura Mountains.

The causes of these mountain foldings may possibly be the lateral stress due to local horizontal expansion, if the theory of Mr. Mellard Reade is correct. But a great number of geologists consider that the prime cause of these foldings, and indeed of mountain upheavals, is the contraction of the earth due to its secular cooling. As this contraction goes on, the cold crust has to accommodate itself to the shrinking interior, and in doing this it is necessarily crumpled and wrinkled. The great land masses and the great oceanic troughs of our earth, moreover, lie along lines of longitude. Winchell has attributed this north and south trend of the chief lines of crumpling to the directive influence of the tidal stress.

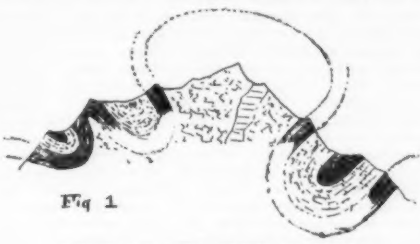
Prof. Lapworth, in his address, stated the case for the contraction theory of mountain origin in a remarkably vivid way. He called attention to the manner in which trough and ridge everywhere corresponded. For the upthrust of America, with its Mississippi Valley and its unilateral ridges of the Rockies and Appalachians, we have the Atlantic with its division by the Dolphin ridge into two parallel troughs; and corresponding to the broad uprise of the older continents we have the great depression of the Pacific. Coming to the shorter transverse foldings, the Alpine mass had for its trough the Mediterranean; and Central Asia the southward deep of the Indian Ocean. This "undulation" of the surface of the solid earth is far more in agreement with the theory of secular cooling than the theory of Mr. Mellard Reade.

On the other hand, there are those who consider the amount of folding we find in mountain masses, which must amount altogether to a diminution of the earth's circumference by many hundred miles, too great for their conception of the amount of contraction the world has undergone since the rocks in question were solidified. Moreover, in certain localities in Sweden and elsewhere, *crumpled rocks are found lying on an undisturbed base*. Prof. Reyer has recently propounded some novel and remarkably suggestive views in this matter.

He has conducted a series of experiments upon the behavior of artificial strata made of muddy material or plaster of Paris mixed with glue and variously tinted. These before complete consolidation were placed on boards slightly tilted (5° to 15°), and the arrangement was occasionally tapped to imitate earthquake shocks. There was a general sliding down and crumpling of the mass, such as might conceivably happen in the case of sedimentary rocks, and sections taken after hardening showed, in consequence of this gliding, beautiful imitations of folding, contortion and faulting such as are seen in mountain chains. Such experiments as this might very easily be repeated by teachers of geology or physiography. They certainly aid the imagination very greatly in thinking out these physiographic problems.

Prof. Reyer's conception of the development of a series of mountain folds, based on experiments of this kind, may be illustrated by the three figures given. While it harmonizes with Mr. Mellard Reade's hypothesis, it seems perhaps a little better adapted to explain complex crumpling of strata than does that supposition. A represents a continental mass, from which the sediments, C, D, E, accumulating in the sea, B, are derived. For manifest reasons, these will be thickest and coarsest near land, where the carrying power of water is at its greatest. Now, on the reasoning already given, this accumulation will finally lead to upheaval, the uprise of strata being greatest in the region where the "blanket" is thickest. That is to say, the base is tilted. The strata consequently glide seaward and pucker up upon the tilted base (Fig. 7). Meanwhile the continental mass (A) is continually undergoing denudation, and the rocks immediately beneath, therefore, are cooling. We may say that the young land to the right is pulling the blanket off its older neighbor, the area, A. The cooling of A causes a subsidence and faulting, and the faulting, weakened, and sinking crust is there least able to resist eruptive material, so that at last (Fig. 8) a volcanic chain, F F F, may grow up behind the fold chain.

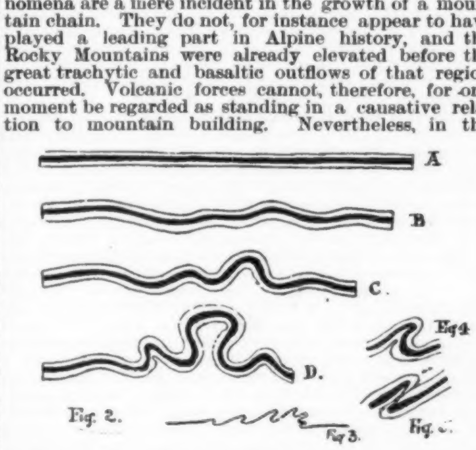
This, briefly, is the story suggested by Prof. Reyer,



SECTION OF MONT BLANC.

a story also fairly consistent with existing mountain structures. But it need not be regarded as a theory absolutely opposed to that so clearly propounded to the English student by Prof. Lapworth. The heating effect of deposition suggested by Mr. Mellard Reade, the crust contraction to which Prof. Lapworth gives prominence, the "gliding" of Prof. Reyer, are all causes that must operate. Prof. Reyer's theory may explain many cases of folding, Mr. Mellard Reade's many cases of upheaval, and yet the great wrinkles on the face of Mother Earth may be due to her withering as the warmth of her youth departs from her.

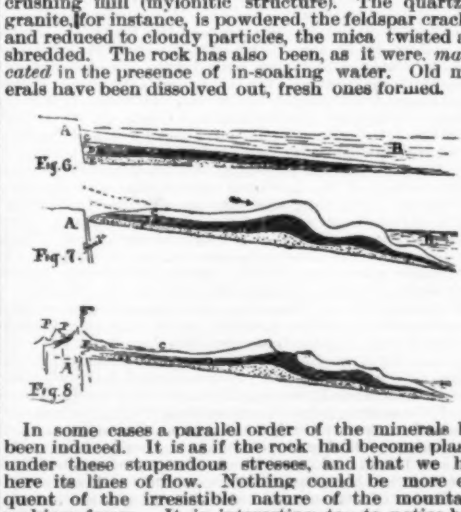
Clearly, from what has been said, volcanic phenomena are a mere incident in the growth of a mountain chain. They do not, for instance appear to have played a leading part in Alpine history, and the Rocky Mountains were already elevated before the great trachytic and basaltic outflows of that region occurred. Volcanic forces cannot, therefore, for one moment be regarded as standing in a causative relation to mountain building. Nevertheless, in the



Andes and the Himalayas the abundant presence of volcanoes is food for thought. However, the question of the causes of volcanic action scarcely belongs to this paper.

Here we may allude to a third feature of mountain structure. It emphasizes the enormous pressures to which the folded rocks were subjected. It is the alteration of the microscopic structure of these rocks.

We find, for instance, clays, with all their once higgledy-piggledy particles, twisted round into a direction at right angles to the force of compression, so that they can be split up into laminæ, and are no longer clays but slates. Limestones lose the traces of their organic relics and become recrystallized as marble. Some rocks are seen with their constituent minerals literally crushed and rolled over and into one another, as though they had been through a colossal crushing mill (mylonitic structure). The quartz of granite, for instance, is powdered, the feldspar cracked and reduced to cloudy particles, the mica twisted and shredded. The rock has also been, as it were, *masticated* in the presence of in-soaking water. Old minerals have been dissolved out, fresh ones formed.



In some cases a parallel order of the minerals has been induced. It is as if the rock had become plastic under these stupendous stresses, and that we had here its lines of flow. Nothing could be more eloquent of the irresistible nature of the mountain-making forces. It is interesting too to notice how we have thus repeated, in a thin flake of rock that would scarcely weigh a grain, the same story of enormous lateral pressure that we find in considering the stratigraphical structure of an Alpine *massif*.

To summarize our deductions, we have in the history of every great mountain chain the following phases. We can do without any appeal to "old Seismos" now to account for the elevation. A long period of quiet subsidence and deposition of sediment is followed by upheaval. There is a process of lateral compression relieved by a bulging, the formation of a ridge or ridges, with troughs on either side. Probably there are no great paroxysms; the steady squeezing and upward creep goes on day by day, year by year, age by age. Strata are imperceptibly thrown into bends, into loops, the foldings are heaped up one above the other, overfolds are formed. The rising mass slowly becomes a prominent terrestrial feature. Stresses, culminating day by day, are at last relieved by the formation of faults and thrust planes, and as the ruptured strata slip there are earthquakes. Rocks are crushed and metamorphosed, softened, moulded, possibly even liquefied. There may be volcanic outbursts along the axis or upon the margins of the rising area.

The emerging mass becomes subjected to denudation. In the main troughs which will be sinking beside the rising ridge, forming seas or lakes, sediments will accumulate. Presently these areas cease to subside and become involved in a greater movement of elevation, as is shown by the Swiss *molasse* and the Siwalik rocks on the Himalaya flanks. So the vast growth continues. Strata tilted on its rising shoulders slide and are crumpled. Above, the snow and glacier are soon at work—unequal heating by day and frost by night, rain and wind splinter the metamorphosed upturned rock masses into peak and pinnacle, cirque and precipice. Thus in the course of ages the mountain chain attains its prime, and a brief equilibrium follows.

But the forces of lateral pressure and upheaval are dying away or they have found a weaker area elsewhere. The volcanoes become extinct, the earthquakes less violent and less frequent. Every moment a hundred streams carry away their quota of material suspended or dissolved. So the period of decay sets in. From the still eruptive Himalayas we may turn to the more quiescent Alps, from there again to the worn-down masses of Scandinavia and Scotland, from there to the still more ancient mountain range half buried beneath the strata of Wales and central England; and so the story ends at last as it began, in sedimentation in the sea.

In conclusion, attention may be called to the rather remarkable fact that in the moon no great meridional mountain ridges, such as one might expect from the analogy of the earth, are to be traced. Neither have the mountains of the moon so distinctly the linear ridge-like arrangement characteristic of terrestrial mountain axes. One might have anticipated, on the contrary, in the absence of an atmosphere and atmospheric denudation and with feebler gravitational attraction, that broad regions of crust folding would have been more conspicuous than on the earth. It may be that these features have been masked by the subsequent precipitation of the lunar atmosphere; but the volcanic character of lunar scenery is hardly consistent with this hypothesis. This, however, is a question for the astronomer to consider.—*Knowledge*.

THE NEW PHYSICAL GEOGRAPHY.

By RALPH S. TARR.

AMONG the many instructive lessons which the study of the geology of the far West has taught, perhaps the most important is the fact that physical geography and geology are inter-related sciences. If one examine a text book of physical geography, he finds that it deals in the main with descriptions and statistics. A river is described as of three parts, the torrential, valley and flood plain portions; it has a divide, perhaps a delta, certain tributaries which rise here or there; it flows in this or that direction, and empties into a certain sea or ocean; and it has a given length and drains so many thousand square miles of surface. A mountain has a certain position, height and trend. In other words, the geographical side is fully presented; but the physical side is practically neglected.

Turning now to the monographs of Powell, Gilbert, Dutton, Russell and others, one finds that land form is regarded from the standpoint of origin and history, and that certain laws are stated by which these forms are derived. This is the nucleus about which much progress has been made toward the foundation of a science of physiography, or, if one prefers, of physical geography. While some Germans and Frenchmen and a few English writers have aided in the establishment of this science, it may, I think, be called essentially an American science, as it now stands. The writers named above, with Chamberlain, Salisbury, McGee, Davis and a few others, have shown how intimately land form is dependent upon structure and physical conditions, and that mountains, valleys, lakes and shore lines have all had a history which is readable, in part at least, by a study of their form and position. By them geology is made to serve in the explanation of land form, and land form is used to interpret geological history, so that the two sciences are made interdependent.

To each of these several writers much credit belongs for his part in the work, and it would be a task of much difficulty to award to each his full share of credit; but to Prof. Davis we owe much, not only for his original researches in the subject, but also formulation of a systematic statement of the history and development of geographical forms. This new science of physical geography he has been developing for years, with the aid of the other physiographers, and has established at Harvard a school of physical geography which is serving as a model for similar schools in some of the large colleges of the country. It is my purpose to state in outline some of the principles of this science, as I interpret them, though in a short article such a presentation must of necessity be incomplete.

Until recently river valleys have been looked upon as definite forms and in a measure unchangeable. Men who are still active in science, Prof. Dana, for instance, took part in the controversy which resulted in the now fully accepted view that river valleys were formed not by faults or cracks in the earth, or by floods, but by the streams themselves, and the general agents of denudation. When this view became firmly established, it was of necessity recognized that such valleys changed in form, but the exact nature of

the change has only recently been detected. That a river valley is young, mature or old, and that by certain peculiarities the relative age, or perhaps more properly the topographic age, can be recognized is a distinctly recent advance. The simplicity of the problem is obscured by the fact that accidents to river valleys are common, and tend to introduce complications, and this may account for the failure to recognize the operation of the law of development of valley form.

A river commencing the development of its valley has certain features which stamp it as young, and though these features may vary in detail, they are in general character the same, whether the development be upon plain, plateau or mountain. Climate, elevation, structure and altitude of the rocks all tend to introduce complications, and produce a marked effect upon the future development, but the main features are reproduced at the various stages of the valley history. In an arid climate the development is less rapid than in a moist climate, and the features of youth consequently remain longer. In a region of hard rocks the development is liable to be less rapid than in one of soft, incoherent, strata unless the load furnished to the river is more than it can carry, thus preventing it from cutting down toward base level. Moreover, the prominent features of youth are preserved in the former for a longer time than in the latter. The development differs in regions of horizontal rocks from that in a country where the strata are inclined, and a low plain will be much sooner reduced to a condition of topographic old age than a high plateau. The element of time, therefore, must be eliminated, and we must distinguish between old age in years and old age in form.

For the sake of simplicity, I will trace briefly the history of a plain of moderate elevation, following in this the example of Prof. Davis in his first article upon the subject. Such a plain would, in all probability, have a general slope in a certain direction down which the drainage would flow, eventually gathering into a channel. This channel might be very irregular, but, in any event, it would be consequent on the original topography. In the hollows, if any existed, lakes would gather, which would act as temporary base levels below which the stream could not cut until they were removed. One of the first tasks of a river would, therefore, be the removal of lakes from its path, which could be done either by cutting down the barrier or filling up the basin, and probably both would co-operate. Lakes in a river's course are, therefore, signs of youth, though this condition is often produced by accidents, which rejuvenate the stream.

A river has for its work two tasks—the carving out of a channel and the transportation of material furnished to it by the disintegration of the rocks. By the two processes combined the river valley is formed and the general land surface lowered. The river itself in its channel does comparatively little work, the chief work being done by the destructive atmospheric agents and by the water as it percolates through the soil or gathers in little rills and moves down the slope. When by the gathering together of these supplies of water into rivulets, and later into rivers, a large body of water is accumulated into a single channel, there is a concentration of action along a narrow line which is the channel of the stream. Here the down cutting of land proceeds with comparative rapidity, but it is confined to the corrosive and erosive action of the river upon its channel bottom. By the slow swinging from one part of the valley to another, to some extent, the scope of this action is increased. The main action of the river, aside from its transporting work, is to lower its channel to as near base level as is possible; but the valley is broadened by the much slower and less perceptible action of subaerial denudation. That this is so is plainly shown by examining the prevailing valley type in arid and in moist regions. Where rains are rare the stream valleys are canons, because of this slower action, while in moist countries the prevailing valley type is broad, with gentle slope. The same form will come in time in arid regions, but it takes much longer to produce it.

When a stream is high above base level, as it would be upon the surface of our young plain, there is an important task before it which must be accomplished as rapidly as possible, and this is the lowering of its channel to as near base level as is consistent with its work as a transporter. Sometimes it is interrupted in this, and sometimes the channel is cut lower than it should have been, and an increased supply of sediment forces it to repair the error by building up its channel. This normal slope may be called the profile of equilibrium, and this may vary in form as the sediment supply varies. The form produced by this effort of the river is a narrow valley, with steeply sloping walls—a gorge or a canon, or a V-shaped valley. This results because the rate of down cutting is in excess of the general denudation. When, however, the channel can be lowered rapidly no longer, the rate of general denudation exceeds the rate of down cutting and the valley walls become farther apart and lower, and a broad slope is produced. The narrow canon-like valley is, therefore, also a sign of youth.

At first our plain is only partly drained, and between the branches are flat-topped divides, upon which, perhaps, the water stands in swampy areas. Such flat-topped divides are seen in the valley of the Red River of the North, upon which the streams are still young, flowing in V-shaped valleys cut in the lake sediment of a body of water which disappeared as the ice retreated from the country. As the stream develops there is an effort to reclaim all land and bring it into a well drained condition; and by the headwater erosion of the streams this is accomplished, so that water which falls upon any part of the land finds a way prepared for it and the divides are reduced to ridges.

A profile of equilibrium must be one not only without basins but also without abrupt descents, and therefore a stream which has falls or rapids in its course must be considered as young, for it has not produced a profile of equilibrium. Waterfalls may be original in the path of the young stream, but more commonly they are developed by the stream as it lowers its channel toward base level. A spur of hard rock, such as might occur in its path in a region of tilted strata, or in a region traversed by dikes, would cause falls, but the great majority of rapids and waterfalls in a river course occur where the rocks are horizontal and of alternating hardness. They occur here more abundantly than elsewhere, chiefly because as a fall is produced at a given point it retreats up stream, and as long as the peculiar conditions last the fall lasts. In regions of horizontal strata the conditions exist over the entire area, but in vertical strata the stream rids itself of the rapid or fall when it has at this point lowered its valley to the profile of equilibrium. In the case of Niagara the fall was at the bluff near Queenstown, but it has retreated seven miles up stream; while if the fall had begun in tilted rocks, it would have existed practically no longer than it was necessary to cut down to the present level in the neighborhood of the original fall.

In speaking of the age of a river valley it is necessary to bear in mind that in different parts of t e stream the topographic form is different. Then the development is more rapid near the mouth than at the headwaters, and here falls may linger even after topographic maturity has been reached lower down the valley. Then, too, the headwaters may be in mountainous regions, where the task before the stream is much greater, while the power of performing it is reduced.

Youth, with its lakes, falls, and narrow valleys, gives place to maturity, where these have disappeared, except perhaps in the upper tributaries. The valley broadens out, particularly in its lower portion, and the channel slope is moderate. Its chief work is now that of a transporter of drainage and of sediment, and this it accomplishes as long as the land will furnish the sediment; but eventually old age must come to it, when the land is reduced to low hills and shallow valleys and the sediment supply is scant. This is a hypothetical stage, for we know of no truly old river valleys, though given time and long-continued freedom from land elevation, this must be the ultimate form of all land.

There are many minor details in the history of a river valley, and no valley has probably passed through this simple cycle, though all tend to do so and all show that they are in one part of it, usually the youngest. At the headwaters there are contests between opposing streams which may result in the robbing of one stream by another of some of its tributaries. Some streams find themselves superimposed upon a structure with which they are not in accord, and they slowly adapt themselves to the structure, and even mutually adjust their courses. These interesting and somewhat complicated phenomena we cannot consider here, but it may be said that they are sometimes apparent in the topography, or in the course of the stream, or in the surrounding conditions.

The chief complications which occur in the history of a stream valley are those arising from external accidents. The growth of a mountain across a valley may dam up, divert, or even reverse the course of a stream. A lava flow may do the same. Climatic change from moist to arid may greatly alter the conditions, and if in a great basin, the evaporation of a lake will not only give to the streams which flow into it the conditions of youth, but will introduce other peculiarities. Among other things a river system will be dissected by evaporation, as the Columbia has been by the cutting off of the tributaries which now empty into the basin of the Great Salt Lake. Climatic change from temperate to glacial at first covers the surface of the country with ice, which, becoming a glacier, moves over its surface and when it disappears leaves it littered with drift which clogs the stream valleys, forms lakes and falls in the river course and diverts the streams from their valleys, forcing them to carve new ones. It is for this reason that our glaciated regions are the seat of so many lakes, falls and gorges; the country seems young, for it has been partly rejuvenated by the glacial accident.

By elevation of the land the streams are revived and given new work to perform; by depression the valleys are buried beneath the sea or fjorded, as upon the New England coast. These changes in the land and these accidents are frequent, and no sooner has a stream valley become partly perfected than a change comes and it is revived or retarded, and the cycle of development interfered with, and this is why we see no old stream valleys and why youthful characters are generally more common than mature forms. Knowing, however, what is the normal tendency, and knowing, also, something of the accidents to which stream valleys are subjected and what in general their effect is, we are often able to base a very correct interpretation of the history of a region from its valley form. A most instructive example of this is found in Dutton's monograph on the Grand Canon of the Colorado. Here the canon is of two parts, an inner narrow canon and an outer and upper broad one, the two being separated by a bench and the upper one being much more degraded than the lower one. Dutton's interpretation is this, that the stream cut down to approximately the level of the bench and here reached its profile of equilibrium, the land being then lower. For a long time the stream stayed at this level and the canon walls retreated farther from the stream and became degraded. Following this rose an elevation culminating in the present level of the plateau, and the inner canon is the result of this more recent work. This interpretation of the phenomena is in perfect accord with what one would expect to happen under such circumstances, and can be accepted as correct.

The study of land form upon the basis of history and development calls for a much more natural classification of topographic features than has been customary, and for a more scientific consideration of them. Lakes are, for instance, to be considered parts of river systems and should be classified upon this basis. There are, for instance, lakes of consequent origin, such as one would find upon a newly born plain. From the normal development of streams other lakes result, such as the ox-horn lakes, and those which are formed upon deltas by the irregular deposit of sediment. By the overburdening of a stream with sediment its channel may be built up and the side streams laked or the side stream may throw a bar across the main stream and form a lake. All these may be called lakes of normal development. Other lakes, and by far the greater number, may be considered as accidental, for they result from some accident to the river valley. The rocks may be folded across its course, or a lava flow may dam back the stream, or a lake may result from glacial interposition.

Mountains also are capable of consideration and classification from the standpoint of origin. By the various kinds of folds or faults different types are produced, and these types all pass through a certain development the features of which may be defined and recognized. A young mountain has lakes, and its streams are in large part consequent upon the topography. A mature mountain has freed itself from these youthful characteristics, and its streams are in accord with the structure rather than the original topography; and, as in the Appalachians, we may find synclinal mountains and anticlinal valleys, instead of anticlinal mountains and synclinal valleys, as in young mountains like the Jura. The ultimate old age form would be a gently rolling plain like that which New England was, possibly, before the tertiary elevation, which allowed the streams to carve out their present valleys.

Shore lines also show certain forms as they proceed in development, and the system can be carried to all land forms. Such a study then gives to land form an added interest, for we see expressed by it an interesting history. During the past year I have written a series of articles for *Goldthwaite's Geographical Magazine*, descriptive of the history of river valleys, giving more detail than in the above a summarized statement of the subject. In closing the series I called attention to what seems to me a great fault among travelers and geographers, and it is a matter which I believe to be of sufficient importance to bear repetition, and I will close by quoting it.

"This is a great field and one in which nearly every intelligent person can do some work. Problems of interest lie at nearly every one's door. How are the plains, the hills, the mountains, the shores, the river valleys found, and by what stages have they come to their present condition? These are questions which every one can ask himself, and they are capable of solution. All these things have had a history, and although the early pages may be partly destroyed, or even lost, there are some pages that can be seen, and read. Even if they are incapable of being read and interpreted by the local observer, it is within his power to record an accurate description which will be of service to those who are more skilled in interpretation.

"A year ago I had occasion to examine carefully many hundred books and magazines, in the hope of finding such descriptions as would allow me to place some interpretation upon their history. This was for the purpose of finding examples of various phenomena in river development. To my surprise, I found that descriptions of sufficient detail were very rare, almost wanting in fact. The very points which were necessary to show the history were, as a rule, omitted. This was particularly true of works of travel and articles by travelers in geographical magazines. Distances, directions, elevations, descriptions of people and animals were very well given, but facts relating to physical geography were almost entirely omitted. I was finally forced to give up my search in geographical magazines and confine my attention to geological works, where in a measure I was able to find what I needed.

"To illustrate the poverty in this direction exhibited by geographic descriptions, I may say that a careful search though all the available literature failed to give any description which would furnish a clew to the cause for the remarkable bifurcation of the river Cassiquiare.

"Travelers may not be able to tell the age of a rock nor to show the relation of one series to another; but there are facts of great interest to a physiographic geologist or a physical geographer which are in plain sight. If the traveler would but describe what he sees and see what there is to describe, much of value could be added to his work."

THE ANNUAL EXHIBITION OF THE MINERALOGICAL DEPARTMENT OF THE BROOKLYN INSTITUTE.

THE well-lighted room at the Art Association Galleries in Montague Street was an excellent place for the exhibition which closed on the evening of Nov. 25. Previous exhibitions have all had interesting features; this, the fourth, was, I think, most significant on account of the number of choice specimens shown and the full representation of certain minerals in single collections.

Mr. Fred. Braun, the indefatigable collector and well known dealer, had a long line of cases filled with minerals gathered in New York City.

A rather large specimen of the narrow banded serpentine and calcite, called "eozoon," was found on One Hundred and Thirty-third Street; brown and black tourmalines in One Hundred and Fifty-ninth Street; cyanite with quartz and gneiss but with enough of its characteristic luster to be beautiful, as well as kaolinite in rather large masses, stilbite and titanite, were all picked up in One Hundred and Sixty-ninth Street.

The serpentines were the choicest specimens in Mr J. Walker's case. They numbered eighty-five, and included a dark rich example of precious serpentine, one of pale green inclosing tufts of hornblende, and porcellophite, all from Stapleton, Staten Island. The rare and beautiful red specimen containing fine lines of olive green came from Lancaster Co., Penn. Mr. Walker also showed very fine natrolites, one of them was in stellate form on datolite; these, as well as the examples of apophyllite, heulandite, analcite, and pectolite, were all taken from the new tunnel at Shady Side, New Jersey.

A number of exhibitors showed specimens of prehnite from Paterson, New Jersey, which were rare on account of their size and depth of color. From there also datolite and stilbite have been brought. Mr. J. W. Freckleton's case contained some of the best of all the same varieties. Besides these, he showed a polished section of a stalactite, and small whole stalactites from Luray Cave, several highly iridescent botryoidal and stalactitic specimens of limonite, and small but clear rhodonites from Franklin Furnace, N. J. The large crystals of mica in his case were found at Edenville, N. Y. Among his most interesting objects were a long, thick mass of lava and some Pele's hair from the volcano of Manua Loa.

Dr. Joseph Hunt, former president of the department, brought from his large cabinet only Mexican minerals and gems. He showed opals with the yel-

low and fire red reflections commonly found in those from that country. His amethysts have unusual depth of color; one or two of them are curious from having here and there crystals of dog-tooth spar on the surface. He showed both black and spotted black and red obsidian. The beautiful rose garnets, some free, others still in the matrix, came from Kalistoe.

Mr. T. B. Jones' collection contained some small specimens of rare beauty; among these the Australian opals were prominent. A bit of brilliant labradorite is made more valuable by having an antique head cut in a depression in it.

The Bozak Mineralogical Club, composed, I am told, of students of the Adelphi Academy, may well be proud of their collection. The native copper in large masses of fantastic form from Michigan, the piece of rose quartz from Branchville, Conn., and a mass of crinoid stems from Williamsville, Erie County, N. Y., were among the striking features of their exhibit. In the next case I found what was to me the most beautiful single collection of the whole exhibition. It was sent by Mr. Chas. H. Pennypacker, of Chester, Penn., and consisted of smithsonite from Laurium, Greece.

The pieces are massive and stalactitic, and some may be incrustations; the colors are exquisite robin's egg blue, apple green, and brown deepening into a rich red.

Here and there, in other cases, I noticed small bits of this ore as well as adamite, which were also from the same locality in Greece.

Prof. D. S. Martin had some especially interesting specimens; among them were the largest piece of prehnite from Paterson and an almost equally large natrolite from the N. Y., S. & W. tunnel in New Jersey. A piece of brownish-gray somewhat clay-like looking substance was labeled "turba," and described as white peat from late tertiary or recent deposits, used for gas making in Bahia, Brazil. Beside it was a bit of lignite found on Disco Island, off the coast of Greenland, and used in the furnaces of the Juniata on the Hall relief expedition.

There were other very interesting specimens, which contributed as much as those I have mentioned to make this exhibition a source of pleasure and education to those who saw them, and to prove, if proof were needed, that this department is one of the strongest in the Institute. A. D.

DEVELOPMENT OF MINERALOGY.—II.*

By L. P. GRATACAP.

Pliny's Book on Gems.

AT the outset our author rehearses the many qualities of gems which have attracted men and placed them among the choice and unattainable products of nature. He attributes this violent flame of admiration for gems to their use in rings, and alludes to the old story of Prometheus wearing in an iron ring upon his finger a fragment of the rock to which he was or had been chained. He tells the fable of King Polycrates, whose unfailing fortune awoke in him fears of some overhanging calamity, and who to avert Nemesis threw a precious gem-bearing ring into the sea, which was again returned to him in the belly of a fish, which from its great size had been considered worthy of the royal kitchen. He alludes to the agate of Pyrrhus, upon which plastic nature, not art, had impressed the group of the nine Muses and Apollo holding his harp, while the *insignia* of each Muse was appropriately reproduced. Gems were, he says, at a very early period cut, and we learn that the great Alexander forbade any stone to be engraved with his face unless the work was executed by Pyrgoteles, an accomplished workman, and who was succeeded by Apollonides and Cronius in the glyptic art. This art soon rose in importance, its professors were highly esteemed, and their workmanship offered to the gods, and in this way the nature, properties, and features of gem stones were more closely studied and their localities more constantly recorded. *Murrhina*, which Pliny first mentions in connection with the wine vessels of Nero and Pompey, is our chalcedony, the amorphous form of quartz. He alludes to its origin as a condensation of moisture by heat, under the earth, a physical conception which would appear particularly erratic to the youngest students of to-day; he mentions its variety of color, with distributed spots in the pervading purple, now assuming the appearance of "ruddy milk" and now putting on the colors of the rainbow. *Crystal*, our quartz, elicits a further physical theory as to its apposite origin from moisture congealed by extreme cold, and this supposition seems warranted to Pliny, as he says "it certainly is nowhere found other than in those places where the rigor of winter snows prevails; certainly it is ice (glaciem), whence the Greeks derive its name." Among many localities he mentions the Alps of Europe, which have to-day furnished such large and handsome specimens. He notes its occurrence in mountainous regions, its deportation from eminences by mountain torrents, and quotes Sudines as averring that it arises (nasci) only in places having a boreal position. He is puzzled over its six-sided form, for which he fails to find any explanation, all the more since these angular summits are not always alike, and have faces smoother than any art could impart. The largest quartz seen by Pliny was one which Livia Augustus dedicated to the Capitoline Jupiter, of the weight of fifty pounds. He enumerates the defects of quartz, as its ferruginous roughnesses, cloudy spots, hidden or interior "tumours," red rust (rubigo), and chinks resembling the finer rootlets of plants.

Amber (succinum) follows quartz as a natural product devoted to luxurious uses. Its mythical origin in the tears of the sisters of Phaeton, who were turned into poplar trees by the bolt of Jupiter, or as an exudation from trees on the Adriatic at the rising of the Dog star points conclusively to a recognition of its resinous and vegetable character, while the curious fable of Demostratus that it pertained to the urine of the lynx indicates also the belief in its organic nature. Sotacus, however, credited it to certain rocks in Brittany from which it escaped—the *electrides*. It was then traced to northern Germany in the Baltic, from whose depths it had been thrust by storms upon the land and was called "the purge of the solidified (concreti) sea," while other philosophers referred its origin to the vehement action of the rays of the setting sun, which hardened the "unctuous sweat" (pinguem sudorem) which, escaping to the sea, was returned by storms to the land.

Numerous localities for amber are given, and to many some peculiar fable was attached explaining the source of this fossil resin. The Garden of the Hesperides, for instance, dropped it in a swamp, where it was collected by the Hesperidae, while the poet Sophocles perpetuated the legend of its being the tears of the Meleager birds, a fancy that Pliny scores with a sharp expression of contempt. But Pliny expresses firmly for himself the conviction that electrum (amber) arises from the "dropping marrow of a tree of the pine kind, as gum in cherry trees and resin in pine;" that it is congealed and carried by storms into the sea, whence again it reappears upon the northern shores. He attributes to it, as usual, medicinal properties, resisting tonsilitis, and troubles of the jaw, and such ailments (goiter ?) of the neck as arise from drinking certain waters; also fevers, obscurity of the eyes and deafness. He alludes to a mass weighing thirteen pounds. Pliny separates the ambers into varieties according to color and surface. He alludes naturally to its electric properties, "for being rubbed by the fingers it receives the animation of warmth and draws unto itself straws and dry leaves such as are light."

Pliny discusses *lyncurium*, of which Theophrastus before him had written, "equally wonderful is the lyncurium (for out of this signets are made); it is hard, it attracts as amber; it is the hardened urine of the lynx; it is found by digging; . . . for the animal endeavors to conceal the deposit by scraping up the earth after voiding." Pliny treats all this incredulously and refers lyncurium to amber. King, however, says "there can be no doubt that the gem described by Theophrastus is our jacinth (zircon), the yellow jargoon, distinguished by having for its chemical base the earth zirconia, peculiar to this family." Pliny assigns to the diamond the same eminence it possesses to-day. It is the *adamas* of the ancients. He also attempts a classification of its varieties and mentions six. As he has observed the hexagonal form of quartz, he also describes the crystalline appearance of the natural diamond, how it appears "with six angles, polished faces, finished in a point, or pointed at opposite extremities, as if two whip-tops were united by their broadest sides." He mentions its extreme hardness, resisting the blows of hammers, its inertness to fire (ignium victrix natura), and contributes an excellent description of four kinds of diamonds: the Indian, not found with gold (he has just before alluded to the association of the diamond with gold), but similar to *crystal* (quartz); the Arabian, smaller; the *cenchros*, like a millet seed; the Macedonian, found in the gold mines of Philippi, equal to a seed of mustard. After these he mentions the Cyprian, of a blue tint, efficacious in medicine, and the *siderites* steely in splendor, and heavier, yet differing in nature, "for it can be broken by blows, and perforated by the other adamas." These last two varieties have been regarded as sapphires. Pliny attributes many virtues to the diamond; it corrects poison, keeps away madness, expels vain fears, and, as to its infrangibility, if steeped in goat's blood, it can be broken.

Pliny exults with a connoisseur's fervor over the delicate and deep shades of emerald. It alone of gems fills the eye, neither tires. He insists that the eye wearied of other study is refreshed by the aspect of the emerald, which overcomes its lassitude by its "lenient verdancy," that it remains unchanged in sunlight, in shadow, translucent even when thick, as is the quality of water. Pliny attempts to separate twelve varieties, but it is admitted that most of these were plasmas, malachite or chrysocolla. Old authors have held that the ancients were unacquainted with the emerald, but, as King maintains, such keen and adroit recognition of the characteristics of the gem as shown by Pliny leaves little doubt that he was discussing this mineral. As a matter of fact, we know that the ancients possessed this gem, though it was regarded for a long time as unknown previous to the discovery of America, and the Scythian stones first mentioned by Pliny may have been derived from the Ural or Altai mountains, which have in recent times furnished many emeralds. Pliny mentions the Bactrian, "which were said to adhere in the crevices of rocks during the Etesian winds. Then they shone upon the ground, because by these winds the sands were greatly stirred." The Egyptian, which have been assigned to the region about Mount Zubara, where, as King remarks, are extensive abandoned workings from which the ancients may have obtained their material, though late investigations have failed to uncover any specimens. The other eight kinds Pliny refers to copper mines, from which it has been inferred that he spoke of prase, malachite, chrysocolla, and possibly turquois. Pliny, with his extreme sensitivity to visual effects, points out in these stones white cloudlets, spots, foreign bodies, dullness in sunlight, coppery tint, absence of true greenness, loss of color by age and in the sunlight, and complicated mimicries of natural objects. It was indeed the first step toward classification, and where no means were supplied for attaining a knowledge of the inner constitution of minerals, either as chemical or physical aggregates, these superficial appearances, as color, etc., and more obvious properties, as hardness, were alone relied on by the observer. Pliny called *chalcedony* a chrysocolla (?) which he ingeniously describes as fragile, of uncertain color, and resembling the changing tints of the moving necks and tails of peacocks and doves, while *inclined* it appeared more or less translucent, veined and spotted. He may have had in mind something quite different, and the *chatoyant* effects might be referred to some feldspar. Pliny referred the beryl, with excellent judgment, to the emerald (smaragdus), and speaks of its six sides, its length, alludes to its yellow tints (chrysoberyl, chrysolite), with paler varieties called by him chrysoprase, a fourth form hyacinthizontes, and fifth aeroides, which was blue, and by some commentators is regarded as the sapphire, though the contrast in hardness would hardly have escaped the quick appreciation of Pliny. Indeed, it might more probably prove to be a blue topaz, itself scarcely removed in hardness from some of the more dense beryls. Finally Pliny separates the waxy, colorless, and oil colored beryls, exhibiting here, as elsewhere, his certainty of ocular criticism.

The opal appeals to Pliny's best mineralogical instincts, and he has left us an unexcelled description of its ardent beauty. "Made up of the splendors of precious stones, it is unspeakably difficult to describe it. In it is the tender fire of the carbuncle, the shining purple of the amethyst, the sea green of the emerald, all shining in an incredible mixture. Some with the greatest access of luster equal the colors of painters, others the fervid flame of sulphur, or fires quickened with oil." He speaks of the defects of the opal, as when its color declines into heliotrope, or it is pale, or presents flaws, or specks meet the observing eye. He mentions its successful counterfeiting, and indicates as a test of quality the scattering radiance of the stone as it is moved hither and thither. He speaks of their being found principally in India, but also in Egypt, Arabia, Galatia, Thasos Pontus and Cyprus. The onyx and sardonyx are mentioned by Pliny and their home is given as in India. The former was three-layered, white, red and black, and the latter separated into fiery, black, corneous and veined varieties, while this attractive description of the onyx is worthy of notice: "The true onyx possesses many and white zones with veins, which mingle with a transition of colors quite indescribable, yet returning into a single combination of grateful beauty." Pliny knew of the many shades of garnet stones, and under carbuncles describes them with much success. He says: "In all sorts the masculine are more splendid, the feminine more dull. In the male gems some are seen of a liquid brilliancy, others black, certain ones pale, and some flashing more in the sun. The best are the *amethystizontes*, that is those of which the fire expires as it were in the violet of the amethyst. Next to these come those called *sititas*, shining with an interior refulgence. They are found everywhere, revealed by the reflection of the sun. Satyrus says the Indian stones are not clear, many being turgid, and of a gloomy luster. The Ethiopian stones are fat, not emitting light but burning with a concealed fire. Callistratus is of opinion that the fire of the carbuncle should be white, nebulous at a distance, if near at hand gleaming brilliantly. On this account, by many this carbuncle is called *candidum*. Those of India which shine more dimly and lividly are called *lithizontes*. The Carthaginian are smaller, barely equaling one-sixth of the Indian gems. Archelaus says the aspect of the Carthaginian to be darker, but when turned to a flame or the sun to be more vividly excited than others. The same in the shade is seen to be purple, under the open ruddy, flashing back the rays of the sun. Among the Carthaginian the male gems shine with a star-like interior flame, the females diffusing a universal light beyond themselves. The alabandine are blacker and more defective than the rest." Pliny speaks of artificial garnets and points out means for their detection. Besides the above varieties of carbuncle (garnet), he instances the garamantic, found in India and Arabia, of which the highest praise was found in the notice of golden drops shining deeply within it, and imitating the heavenly disposition of the Hyades; on this account valued by the Chaldeans.

Pliny's "topazius" is regarded as a distinct stone from the modern topaz, and has been referred to as *peridot* or *chrysolite*. Pliny alludes to its being found upon an island in the Red Sea, of which Diodorus Siculus gravely tells us that it abounded in this gem, whose brilliancy was outshone and deadened by the sun, so that its collectors looked for it at night, when it was conspicuous. The centers of light thus revealed were covered over and the rock with its attached treasure cut out the succeeding day. This identification with the peridot would admit of doubt.

The *callais* of Pliny is considered our turquois, though King argues for its reference to a variety of chrysolite, on the ground partly of its green color, and because of Pliny's expression "full of holes and dross," an incongruous description, if applied to an opaque solid like turquois. Here, as elsewhere, Pliny displays a delicate discrimination in color, and a gemmist's sense of decorative accompaniments in alluding to the reciprocal charm gained by this stone and gold in conjunction. Pliny then enumerates other stones distinguished by their green color, as *prase*, *chrysoprase*, *green jasper*. He notes variations in their color, how they decline into yellow tints and are marked with blood spots (heliotrope), and finally gathers together a series of contrasted stones under the generic appellation of jasper, as emerald green, azure blue (aerizusa), blue, snowy, purple, cloudy, turbid (chalcedon), violet; stones which may be regarded perhaps as varieties of silica, such as we are accustomed, under jasper, chalcedony, quartz and amethyst, to find exhibiting numerous tints and phases of aggregation. The amethyst, indeed, is by Pliny specially designated and, as is his manner, divided into five groups distinguished by color, the imperial purple, the hyacinthine, a lighter tint, the wine colored and the pale crystals. He gives pre-eminence to those which, being held aloft, reveal a "rosy light shining gently in the midst of the purple." Such gems the magi believed resisted inebriety and properly inscribed with the name of the moon or sun and suspended from the neck on the hairs of a dog or the feathers of a dove, overcame venom.

The *hyacinthus* of Pliny has been referred to the sapphire, since Pliny avers its relationship to the amethyst, "differing, in that the violet glory shining from the amethyst is diluted in the hyacinth." The *lyncurium* of the ancients was the modern hyacinth. Referable also to our hyacinth (zircon) may be Pliny's *chryselectrum*, *leucochrysum* and *melichrysum*. The property of asterism is noted by Pliny, with a probable confusion with the allied phenomenon of diffraction called *cat's eye*, or moonstone. He speaks expressively of the "inclosed light like a pupil which is emitted with the tilting of the stone, and, as if oscillating, moving from point to point, and placed opposite to the sun, returning its rays." He indeed speaks of a stone (astrion) found in India which "within from a center like a star shines with the splendor of the full moon," a very suggestive and satisfactory description of adularia.

Agate receives from Pliny a series of synonyms, each name expressive of a peculiarity in the color, shape or markings, which, as every one knows, attain the last degree of mimetic variation. To the agate the Per-

* Continued from SUPPLEMENT 928, page 14836.

sians attributed the greatest potency. It cured the bites of scorpions and spiders, assisted the eyes, quenched thirst, averted storms and repelled thunder, if strung on the mane of a lion. In this connection Pliny mentions a number of fabulous stones which the superstitious practice of his time invested with miraculous virtues. Such were the *alectoria, androdama, argyrodama, antipathes, arabica, aromatitis, batrachites* (toad stones), etc., a long obscure list, with a cloud of mythical fancies attached to them; while their origin in the stomachs of birds, on beasts, in the fading light of the moon, etc., their power to reproduce gems, to allay winds, kindle fires, overcome the strategy of savages (*hematite*) and work successful charms, or endow with rare gifts of mind and person their wearers—all constitute a singular and graphic portraiture of the traditional lore attached to stones and the inherent tendency of the primitive mind to necromancy and superstition.

Pliny concludes his remarkable essay with observations upon the imitations of gems, colorations of stones and their preferable forms in nature, and some rules for their detection.

The thirty-seventh book of Pliny's "Treasury of Knowledge" in the first century forms a capital presentation of the state of mineralogical science in that early day. Taken in connection with his work on stones and ores, it shows us how eagerly the eyes of men had surveyed the earth's surface and to what extent, guided by their uses, their most obvious physical characters and their colors, the barely emergent science of mineralogy had progressed. Many distinctions which we now retain had been made, a number of names persistent to-day applied, and a faculty of criticism aroused. Pliny's work represented the consolidated wisdom of his time in mineralogy, as he was himself the heir of all previous mineralogical study, and this book justly may be regarded as the initial effort at a system and text book of mineralogy.

THE TALLEST MAMMAL.

By R. Lydekker, B.A.Cantab.

Compared with their extinct allies of earlier periods of the earth's history, it may be laid down as a general rule that the large animals of the present day are decidedly inferior in point of size. During the later portion of the tertiary period, for instance, before the incoming of the glacial epoch, when mammals appear to have attained their maximum development, there lived elephants alongside of which ordinary individuals of the existing species would have looked almost dwarfs, while the cave bear and the cave hyena attained considerably larger dimensions than their living representatives, and some of the saber-toothed tigers must have been considerably larger than the biggest African lion or Bengal lion. Again, the remains of red deer, bison, and wild oxen, disinterred from the cavern and other superficial deposits of this country, indicate animals far superior in size to their degenerate descendants of the present day; while some of the extinct pigs from the Siwalik Hills of northern India might be compared in stature to a tapir rather than to an ordinary wild boar. The same story is told by reptiles, the giant tortoise of the Siwalik Hills, in spite of its dimensions having been considerably exaggerated, greatly exceeding in size the largest living giant tortoises of either the Mascarene or the Galapagos Islands. The latter rocks have also yielded the remains of a long-snouted crocodile, allied to the gavial of the Ganges, which probably measured from fifty to sixty feet in length, whereas it is very doubtful if any existing member of the order exceeds half the smaller of these dimensions. If, moreover, we took into account totally extinct types, such as the megatheres and mylodons of South America, and contrasted them with their nearest living allies—in this instance the sloths and ant-eaters—the discrepancy in size would be still more marked, but such a comparison would scarcely be analogous to the above.

To every rule there is, however, an exception, and there are a few groups of living large mammals whose existing members appear never to have been surpassed in size by their fossil relatives. Foremost among these are the whales, which, as we have seen in a previous article, now appear to include the largest members of the order which have ever existed. The so-called white, or square mouthed, rhinoceros of South Africa seems also to be fully equal in size to any of its extinct ancestors; and the same is certainly true of the giraffe, which may even exceed all its predecessors in this respect. Whether, however, the fossil giraffes, of which more anon, were or were not the equals in height of the largest individuals of the living species, there is no question but that the latter is by far the tallest of all living mammals, and that it was only rivaled in this respect among extinct forms by its aforesaid ancestors. Moreover, if we exclude creatures like some of the gigantic dinosaurian reptiles of the secondary epoch, which, so to speak, gained an unfair advantage as regards height, by sitting up on their hind legs in a kangaroo-like manner, and limit our comparison to such as walk on all four feet in the good old-fashioned way, we shall find that giraffes are not only the tallest mammals, but likewise the tallest of all animals that have ever existed.

In the great majority of animals that have managed to exceed all their kin in height, the increment in stature has been arrived at by lengthening the hind limbs alone, and thus making them the sole or chief support of the body. In some of these cases, as among the living kangaroos and the extinct dinosaurs, the body was raised into a more or less nearly vertical position, and the required height attained without any marked elongation of the neck. In birds, on the other hand, like the ostrich, the body is carried in nearly the same horizontal position as in a quadruped, but both the hind legs and the neck have been elongated. The giraffe, however, has attained its towering stature without any such important departure from the general structure characterizing its nearest allies, and thus preserves all the essential features of an ordinary quadruped. Belonging, as we have had occasion to mention in an earlier article, to the great group of ruminant ungulates, among which it is the sole living representative of a separate family, the giraffe owes its height mainly to the enormous elongation of two of the bones of the legs, coupled with a corresponding lengthening of the vertebræ of the neck. As in all its kindred, the lower segment of each leg of this animal forms a cannon bone, the nature of which has been explained in the article referred to; and in the fore limb it is the bone below the wrist (commonly termed the knee), and the radius above the latter, which have undergone an elongation so extraordinary as to make them quite unlike, as regards proportion, the corresponding elements in the skeleton of a ruminant, such as an ox, although retaining precisely the same structure. Similarly, in the hinder limb, it is the cannon bone below the angle joint or hock, and the tibia or shinbone above, which have been thus elongated. To any one unacquainted with their anatomy, it might well appear that a giraffe and a hippopotamus would differ greatly in regard to the number of vertebræ in their necks; but, nevertheless, both conform in this respect to the ordinary mammalian type, possessing only seven of such segments. Whereas, however, those of the latter animal are very broad and short, in the giraffe they are extremely long and slender, attaining in full grown individuals a length of some ten inches. This remarkable adherence to one numerical type in the neck vertebræ is, indeed, a very curious feature among mammals; the extreme contrasts in respect of form being exhibited by those of the Greenland whale, in which each vertebra is shortened to a broad disk-like shape, and the giraffe, where it is equally narrow and elongated.

As regards the height attained by the male of the tallest of quadrupeds, there is, unfortunately, a lack of accurate information, and since it is probable that the majority of those now living are inferior in size to the largest individuals which existed when the species was far more numerous than at present, it is to be feared that this deficiency in our knowledge is not very likely to be remedied. By some writers the height

THE GIRAFFE.

of the male giraffe is given at sixteen feet and that of the female at fourteen feet, but this is certainly below the reality. For instance, Mr. A. H. Bryden states that a female he shot in southern Africa measured seventeen feet to the summits of the horns; while Sir S. Baker, whose experiences are derived from the north-eastern portion of the continent, asserts that a male will reach as much as nineteen feet, although, most unfortunately, it is not mentioned whether the latter height is merely an estimate or is based upon actual measurement. From the evidence of a very large though badly preserved specimen in the Natural History Museum, it may, however, be inferred that fine males certainly reach the imposing height of eighteen feet.

Although this towering stature is the most obvious external feature of the giraffe, it is not one which would of itself justify the naturalist in classing the animal as the representative of a family apart from other ruminants; and we must accordingly inquire on what grounds such separation is made. On the whole, the most distinctive structural peculiarity of the giraffe is to be found in the nature of its horns. These, as mentioned in our article on "Horns and Antlers," are quite unlike those of any other living ruminant, and take the form of a pair of upright bony projections arising from the summit of the head in both sexes, and completely covered during life with skin. In the immature condition separate from the skull, these horns become in the adult firmly attached to the latter; and below them, in the middle of the forehead, is another lower and broader protuberance, often spoken of as a third horn. Obviously, these horns—for want of a better name—are quite unlike the true horns of the oxen and antelopes, or the antlers of the deer; and this essential difference in their structure is alone quite sufficient to justify the reference of the giraffe to a family all by itself. When, however, we come to inquire whether the creature is more nearly akin to the deer or to the hollow-horned ruminants (as the oxen, antelopes, and their allies are termed), we have a task of considerable difficulty. Relying mainly on the structure of its skull, and its low-crowned grinding teeth, which are invested with a peculiar rugose enamel having much the appearance of the skin of the common black slug, some naturalists speak of the giraffe as a greatly modified deer. A certain justification for this view is, indeed, to be found in the circumstance that the liver of the giraffe, like that of the deer, is usually devoid of a gall bladder. Occasionally, however, that appendage, which is so characteristic of the hollow-horned ruminants, makes its appearance in the giraffe, thus showing that no great importance can be attached to it one way or another. On the other hand, in certain parts of its soft anatomy, the creature under consideration comes very much closer to the antelopes and their kin than to the deer. It would appear, therefore, on the whole, that the giraffe occupies a position midway between the deer on the one hand and the antelopes on the other; while as neither of these three groups can be regarded as the direct descendant of either of the other two, it is clear that we must regard all three as divergent branches from some ancient common stock.

As regards general appearance, the giraffe is too well known to require description, but attention may be directed to a few of its more striking external peculiarities. One remarkable feature is the total lack of the small lateral or spurious hoofs, which are present in the great majority of ruminants, and attain relatively large dimensions in the reindeer and musk deer. Indeed, the only other members of the whole group in which these hoofs are absent are certain antelopes; but this absence cannot be taken as an indication of any affinity between the latter and the giraffe, since it is most probably the result of independent development. Equally noticeable are the large size and prominence of the liquid eyes, and the great length of the extensile tongue; the former being obviously designed to give the creature the greatest possible range of vision, while the extensibility of the latter enhances the capability of reaching the foliage of tall trees afforded by the lengthened limbs and neck. In comparison with the slenderness of the neck, the head of the giraffe appears of relatively large size; but this bulk, which is probably necessary to the proper working of the long tongue, is compensated by the extreme lightness and porous structure of the bones of the skull. Lastly, we may note that the long tail, terminating in a large tuft of black hairs, is a feature unlike any of the deer, although recalling certain of the antelopes.

Somewhat stiff and ungainly in its motions—the small number of vertebræ not admitting of the graceful arching of the neck characterizing the swan and ostrich—the giraffe is in all parts of its organization admirably adapted to a life on open plains dotted over with tall trees, upon which it can browse without fear of competition by any other living creature. Its wide range of vision affords it timely warning of the approach of foes; from the effect of sand storms it is protected by the power of automatically closing its nostrils; while its capacity of existing for months at a time without drinking renders it suited to inhabit waterless districts like the northern part of the great Kalahari desert. And here we may mention in passing that the camel has gained a reputation for being adapted for a desert life above all its allies which is not altogether deserved. It is true, indeed, that a camel can and does make long desert journeys, but these can only be maintained during such time as the supply of water in its specially constructed stomach holds out, and when this fails there is not an animal that sooner knocks up altogether than the so-called "ship of the desert." Did their bodily conformation and general habits admit of their being so employed, there can indeed be little doubt that the giraffe and some of the larger African antelopes, which are likewise independent of water, would form far more useful and satisfactory beasts of burden for desert traveling than the, to our mind, somewhat overrated camel. Returning from this digression, it must be mentioned that when we speak of the giraffe being independent of water, we by no means intend to imply that it never drinks. On the contrary, during the summer this ruminant, when opportunity offers, will drink long and frequently; but it is certain that for more than half the year, in many parts of southern Africa at least, it never takes water at all. In certain districts, as in the northern Kalahari, this abstinence is, from the nature of the country, involuntary; but according to Mr. Bryden, the giraffes living in the neighborhood of the Botletli River—their only source of water—never drink therefrom throughout the spring and winter months. When a giraffe does drink, unless it wades into the stream, it is compelled to straddle its forelegs far apart in order to bring down its lips to the required level, and the same ungainly attitude is perforce assumed on the rare occasions when it grazes.

There is yet one other point to be mentioned in connection with the adaptation of the giraffe to its surroundings before passing on, and this relates to its coloration. When seen within the inclosures of a menagerie—where, by the way, their pallid hue gives but a faint idea of the deep chestnut tinge of the dark blotches on the coat of a wild male—the dappled hide of a giraffe appears conspicuous in the extreme. We are told, however, that among the tall *kameel-dhorn* trees, or giraffe-mimosas, on which they almost exclusively feed, giraffes are the most inconspicuous of all animals; their mottled coats harmonizing so exactly with the weather-beaten stems and with the splashes of light and shade thrown on the ground by the sun shining through the leaves that at a comparatively short distance even the Bushman or Kaffir is frequently at a total loss to distinguish trees from giraffes, or giraffes from trees.

At the present day, it is hardly necessary to mention, the single species of giraffe is exclusively confined to Africa, not even ranging into Syria, where so many other species of animals otherwise characteristic of that continent are found. This restricted distribution was, however, by no means always characteristic of the genus; for during the pliocene period extinct species of these beautiful animals roamed over certain parts of southern Europe and Asia. The first of these extinct giraffes was discovered by Falconer

and Cautley many years ago in that marvelous mausoleum of fossil animals, the Siwalik Hills of northeastern India; remains of the same species being subsequently brought to light in the equivalent deposits of Perim Island, in the Gulf of Cambay, and likewise in the Punjab.

A second species has also left its remains in the newer tertiary rocks of Pikermi, near Athens; while those of a third have been disinterred in China. It was, indeed, believed for a long time that France also was once the home of a member of the genus, but the specimen on which the determination was based is now known to be a jawbone belonging to the existing species. Although we are, unfortunately, unacquainted with the geology of the greater part of Africa, the foregoing evidence points strongly to the conclusion that giraffes (together with ostriches, hippopotami and certain peculiar antelopes) are comparatively recent emigrants into that continent from the northeast; but, as we have elsewhere had occasion to mention, the reason why all these animals have totally died out in their ancient homes is still one of the darkest of enigmas.

Unknown in the countries to the north of the Sahara, as well as in the great forest regions of the west, which are unsuitable to its habits, the giraffe at the present day ranges from the north Kalahari and northern Bechuanaland, in the south, through such portions of eastern and central Africa as are suited to its mode of life, to the southern Sudan in the north. Unhappily, however, this noble animal is almost daily diminishing in numbers throughout a large area of southern and eastern Africa, and its distributional area as steadily shrinking. Whether it was ever found to the south of the Orange River and in the Cape Colony may be a moot point, although, according to Mr. Bryden, there are traditions that it once occurred there.

Apart from this, it is definitely known that about the year 1813 these animals were met with only a little to the north of the last-named river; while as late as 1836 they were still common throughout the Transvaal, and more especially near the junction of the Marico with the Limpopo River. Now their last refuges in these districts are the extreme eastern border of the Transvaal (where only a few remain), and the district lying to the north of Bechuanaland and known as Khama's country, or Bawangwato, together with the northern Kalahari. Even here, however, their existence is threatened, as there is a proposal to put down tube wells in the waterless Kalahari, which, if successfully accomplished, will open up the one great remaining stronghold of the animal to the merciless hunter. Unless, therefore, efficient and prompt measures are taken for its protection, there is but too much reason to fear that the giraffe will ere long be practically exterminated from this part of Africa; although, fortunately, it has a prospect of surviving for many years to come in the Sudan and Kordofan. The great majority of the giraffes killed at the present day in southern Africa are shot solely for the sake of their skins, which are now, owing to the practical extermination of rhinoceroses south of the Zambesi and the ever-increasing scarcity of the hippopotamus, used in the manufacture of the formidable South African whips known as *jamboks*. The value of a skin usually varies, according to size and quality, from £2 10s. to £4, although they have been known to fetch £5 apiece; and it is for the sake of such paltry sums that one of the noblest and most strange of mammals stands in imminent danger of extermination!

We may conclude this notice by mentioning that, although the giraffe was familiar to the Romans of the time of the empire, by whom it was known as the camelopard, it appears to have been almost completely lost sight of in Europe in later times till the closing decades of the eighteenth century, although a single example is stated to have been exhibited alive in Florence some four centuries ago. With that exception, it seems to have been generally regarded as a fabulous animal until one was shot near the Orange River in 1777 by an Englishman, and another by the French naturalist, Le Vaillant, in 1784. From that time onward our knowledge of the animal and its habits gradually increased, although it was not till the spring of 1836 that four living specimens from the Sudan were brought alive to London, where some of their descendants lived continuously till 1892, since which date the species has been unrepresented in the Regent's Park. —*Knowledge*.

PARASITIC AND PREDACEOUS INSECTS IN APPLIED ENTOMOLOGY.*

By C. V. RILEY.

THE importance to man, and especially to the horticulturist, of the parasitic and predaceous insect enemies of such species as injure vegetation has been recognized by almost all writers on economic entomology. Indeed, it is a question whether the earlier writers did not attach too much importance to them, because, while in the abstract they are all essential to keep the plant-feeding species in proper check, and without them these last would unquestionably be far more difficult to manage, yet in the long run our worst insect enemies are not materially affected by them, and the cases where we can artificially encourage the multiplication of the beneficial species are relatively few. While fully appreciating the importance of the subject, therefore, it is my purpose in this paper to point out the dangers and disadvantages resulting from false and exaggerated notions upon it.

There are but two methods by which these insect friends of the farmer can be effectually utilized and encouraged, as, for the most part, they perform their work unseen and unheeded by him, and are practically beyond his control. These methods consist in the intelligent protection of those species which already exist in a given locality, and in the introduction of desirable species which do not already exist there.

The first method offers comparatively few opportunities where the husbandman can accomplish much to his advantage. That a knowledge of the characteristics of these natural enemies may, in some instances, be easily given to him, and will, in such instances, prove of material value, will hardly be denied. The oft-quoted experience which Dr. Asa Fitch recorded, of the man who complained that his rose bushes were more seriously affected with aphides than those of his neighbors, notwithstanding he conscientiously cleaned off all the old parent bugs (he having mistaken the beneficial ladybirds for the parent aphides), may be mentioned in this connection. Other cases will recur to you and I will mention one rather striking experience related by my assistant, Mr. L. O. Howard. The army worm (*Leucania unipuncta*) was overrunning a large and valuable field of timothy and threatened the destruction of the adjoining fields. The insect was as yet, however, circumscribed, and susceptible of remedial treatment. The owner of the field, observing the buzzing swarms of the red-tailed tachina fly, assumed that the fly was the parent of the worms, and as the former was an active, winged creature, capable of extended flight, he concluded that remedial work was useless, since the flies could, and doubtless would, deposit their eggs over the entire surrounding country. As a consequence the worms were allowed to travel to the adjoining fields and the injury thus increased through ignorance of the fact that the tachina flies were the most important of the parasitic enemies of the worm. For many years well informed gardeners in parts of Europe have practiced collecting ladybirds and some of the ground beetles to liberate upon plants infested by plant lice or by cut-worms. The characteristics of these two families, Coccinellidae and Carabidae, should be taught in our schools, as a definite knowledge of certain species, which is readily acquired, may often be turned to account in a limited way by the cultivator.

In a few cases like this there is no reason why the farmer should not be taught, with advantage, to discriminate between his friends and his foes, and to encourage the multiplication of the former; but for the most part the nicer discrimination as to the beneficial species, some of the most important of which are microscopically small, must be left to the trained entomologist. Few of the men practically engaged in agriculture and horticulture can follow the more or less technical characterization of these beneficial species, and where the discriminating knowledge is possessed it can, as just intimated, only exceptionally be turned to practical account. Thus our literature on this subject in the past has been of interest from the entomological rather than from the agricultural point of view, as most writers on economic entomology have contented themselves with describing and illustrating such beneficial species.

In other cases much good may be done without any special knowledge of the beneficial forms, but as a result of a knowledge of the special facts, which enable the farmer to materially encourage the multiplication of parasitic species, while destroying the plant-feeding host.

The rascal leaf-crumpler (*Mineola indiginella*, Z.), a common insect which disfigures and does much damage to our apple and other fruit trees, and which hibernates in cases attached to twigs, is a case in point. Many years ago I urged the importance of preserving the several parasites known to prey upon it in the following language:*

"The orchardist has but to bear in mind that it, the leaf-crumpler, is single-brooded and that it passes the winter in its case. He will understand that by collecting and destroying these cases in the dead of the year when the tree is bare he effectually puts a stop to its increase. . . . Whether collected in winter or pulled off the trees in spring or summer, these cases should always be thrown into some small vessel and deposited in the center of a meadow or field away from any fruit trees. Here the worms will wander about a few yards and soon die from exhaustion and want of food, while such of the parasites, hereafter mentioned, as are developed or in the pupa state will mature and eventually fly off. In this manner, as did Spartacus of old, we swell the ranks of our friends while defeating our foes."

The practical value of this suggestion was subsequently fully demonstrated, and especially by the late D. B. Wier, who, at a meeting of the Illinois Horticultural Society, as secretary of a committee appointed by said society, to consider the best means of securing co-operation in the warfare against the fruit growers' insect enemies, announced that this policy had been followed with happy results.

A similar course was urged by me in the case of our common bag-worm (*Thyridopteryx ephemeraeformis*). This species, as we know, is also subject to parasites, and the bags or cases which are collected in winter, instead of being burned, should be allowed to remain until the middle of the next summer in some vessel well separated from trees and shrubs, in order that the young worms, when they hatch in spring from the eggs contained in the female bag, may perish, while the parasites develop and escape. Prof. J. H. Comstock has suggested in a similar way the placing of the hand-collected chrysalides of the imported cabbage worm (*Pieris rapae*) in boxes covered with wire netting, in order to admit of the ready escape of the little chalcid parasite, *Pteromalus puparum*, and at the same time retain such of the butterflies as may issue—a practice which had, I believe, been successfully employed in Europe. Other similar cases of this mode of encouragement will occur to you, but, as already stated, with comparatively few exceptions, such as those indicated, the multiplication of our parasitic and predaceous species on the line of this first method is practically beyond our control.

It is quite different in the second method of dealing with beneficial insects, for here man has an opportunity of doing some very effective work, and it is only within comparatively recent years that the importance of this particular phase of the subject has been fully realized. The Rev. C. J. S. Bethune, of Canada, was probably the first entomologist to suggest, in one of the earlier volumes of the *Canadian Farmer*, the importation of the European parasites of the wheat midge (*Diplosis tritici*) into America, on the supposition that this cosmopolitan species might thus be kept in check on this continent to the same extent that it was in Europe. So far as I am aware, the attempt was never actually made, and though some subsequent correspondence was entered into between Fitch and Curtis, and later between Walsh and some of his English friends, nothing tangible resulted. The matter was, in fact, never seriously studied with this purpose in view.

The importance of this phase of the subject was early forced upon my attention, as it was upon that of others, and is frequently referred to in my earlier writings. Thus in 1869–70, in studying the parasites of the plum curculio, it became evident that they were of such nature that they could be easily transported from one locality to another, and I distributed from Kirkwood, Mo., *Sigalphus curculionis*, Fitch, and *Porizon conotracheli*, Riley, to several correspondents in other parts of the State. I also urged a similar course with regard to some of the parasites of the Coccidae, which it happens may be easily transported from one place to another in their undeveloped or adolescent stages.* LeBaron, in his studies of the oyster shell bark louse of the apple and one of its parasites (*Aphelinus mytilaspidis*), transported scale-covered twigs during winter from Geneva, Ill., to Galena, Ill., with beneficial results. The experiment was conducted on a small scale, but the parasites issued and became domiciled in their new locality, thus proving the practicability of his scheme. In neither my own experiments nor in LeBaron's, however, was sufficiently thorough examination made to prove that the parasites did not already exist in the localities in which they were colonized. Planchon and myself introduced *Tyroglyphus phylloxerae* from America into France in 1873,† and it became fully established, as subsequent correspondence and observation showed. In 1874 efforts were made to send over from England to New Zealand certain aphid parasites to check the alarming increase of those plant pests there, and while I have no record at hand to show with what success, the later successful introduction of bumble bees to the latter country, to fertilize the red clover, is well known history. In his report upon the parasites of Coccidae in the annual report of the Department of Agriculture for 1880, Mr. Howard gave the subject some theoretical attention and elaborated upon the ease with which coccid parasites could be transported from one part of the country to another during winter. He suggested the experiment of transporting *Dilophogaster californica* from the Pacific coast to certain of the southeastern States, where it might be expected to prey upon certain large species of Lecanium. In 1883, after previous futile attempts by myself and Mr. Otto Lugger, and with the assistance of Mr. G. C. Bignell, Esq., of Plymouth, England, the living cocoons of *Microgaster glomeratus*, a common European parasite of *Pieris rapae*, were successfully imported by the department, and the colonization of the new species was established, not only in the District of Columbia, but in Iowa, Nebraska and Missouri, as specimens were simultaneously sent to the agents of the division in those States.‡ It has become so widely distributed since then as to lead to the inference that it must have been previously introduced at some other points, though the spread of an introduced species, even when introduced at a single point, is often so rapid that it surprises us, especially of a species that is winged, as evidenced by the spread of the horn fly (*Haematobia serrata*) over the whole eastern United States in about four years. Later, in 1891, with the aid of Mr. Fred. Enock, of London, a successful effort was made to introduce into this country from England, an important chalcid parasite of the Hessian fly—*Entedon epigonus*, Walker (*Semiotellus nigripes*, Linn.) The details of this experiment will be found in my published writings, especially in my report as U. S. Entomologist for 1891, and it is only necessary to state at this time that parasitized puparia of the Hessian fly were received in large numbers, and distributed to various points and placed in the care of competent observers in Illinois, Indiana, Michigan and Canada. The results, so far, have not been marked, and but one positive report as to the acclimation of the parasite has been received, viz., from Prof. S. A. Forbes, of Champaign, Ill. I am of the opinion, however, that the lack of evidence from other points is due almost entirely to lack of proper examination, and I have every hope that the species will before long be found to have obtained a secure foothold at all of the several points of introduction. It is a very difficult matter to ascertain the existence of a parasite of this minute size, except when it occurs in great numbers. It requires an eye trained not only to the examination of these minute creatures, but one familiar with the allied imported species and native species. The reason for attempting the introduction of this particular species was simply that in England it was found to be far more abundant and far more beneficial than any of our native species have so far proved.

The present year I have become interested in the matter of the importation of a predaceous noctuid (*Erastria scitula*), which preys upon the black scale (*Lecanium oleae*) in south Europe and helps materially to keep it in check. With the help of Prof. H. Rouzaud, of Montpellier, France, who has studied the habits of this insect with extreme care, I hope to establish it in southern California, where the climatic conditions are sufficiently close to those of south Europe, and where the black scale does great damage to olive orchards and oleander trees, and also affects less seriously the orange and lemon. The black scale has already an important enemy in California in the shape of the dilophogaster above mentioned, but the latter is only two-brooded, and the scale insect multiplying more rapidly, outstrips it in the race. The erastria, on the contrary, passes through five or six generations in the course of a summer, and as it is purely predaceous, it will, I believe, prove a most useful auxiliary against the black scale, especially if brought over without its parasites.

So far I have spoken only of the insects which have been imported into this country, but some effort has also been made in the opposite direction. Thus we have endeavored (and with some success) to return the service done us by sending to Australia and New Zealand some of our predatory coleoptera, some of the Pacific coast parasites of the codling moth, and a species of the interesting genus Raphidia, which also preys upon the codling moth.

In 1887 and 1888 the now well known importation of *Vedalia cardinalis* from Australia and New Zealand to California, to prey upon *Icerya purchasi*, was suc-

* Read before the Association of Economic Entomologists, Madison, Wis., August 18, 1893.

* Fourth Report Insects of Missouri, 1871, p. 40.

* Third Rep. Ins. Mo., 1870, p. 29; Fifth Rep. do., 1873, p. 90.

† Sixth Report Ins. Mo., 1874, p. 56.

‡ Report of the Entomologist, in Rep. U. S. Dep. Agr. for 1884, p. 325.

cessfully carried out. The history of this striking example of the beneficial results that may, in exceptional cases, flow from intelligent effort in this direction, is now sufficiently well known to American economic entomologists; but, anticipating that we shall have foreign delegates among us and that our proceedings will be published more widely than usual, it will, perhaps, be wise to give the salient historical facts in the case, even at the risk of some repetition of what has been already published. In doing this the indulgence of the society is craved for the prominence of my own part in the work, rendered necessary by the disposition in some quarters to distort the facts.

The fluted scale, otherwise known as the white or cottony-cushion scale (*Icerya purchasi*, Maskell), is one of the largest species of its family (Coccidae), and up to 1883 had done immense injury to the orange groves and to many other trees and shrubs of southern California. From Australia, its original home, it had been imported into New Zealand, South Africa and California, the evidence pointing to its introduction into California about 1868, and probably upon *Acacia latifolia*.

In my annual report as United States Entomologist for 1886, will be found a full characterization of the species in all its stages; but the three characteristics which most concern the practical man, and which make it one of the most difficult species to contend with, are its ability to survive for long periods without food, to thrive upon a great variety of plants, and to move about throughout most of its life.

The injuries of this insect, notwithstanding the efforts to check it, kept on increasing, and some ten years ago I felt that the work of this particular species and of others which seriously affected the fruit-growing interests of southern California, justified the establishment of agencies there. Up to this time no special entomological efforts had been made by the government on behalf of the fruit growers of the Pacific coast. Through agents stationed, the one at Los Angeles and the other at Alameda, a course of elaborate experiments was undertaken as to the best means of treating the insects affecting the orange there, and more particularly this fluted or cottony-cushion scale. During the progress of these investigations, however, the fact impressed itself upon my mind that we had here an excellent opportunity of calling to our aid its own natural enemies; for while there were some doubts as to the origin of Icerya, the question was finally settled to my satisfaction that it was of Australian origin, and that in its native home it was not a serious pest, but was kept subdued by natural checks. These facts were not positively ascertained without a good deal of correspondence and investigation, involving in fact a trip to France, as has been set forth in published writings upon the subject.

In my report as United States Entomologist for 1886; in an address before the State Board of Horticulture at Riverside, Cal., in 1887; in a paper before the Philosophical Society of Washington, in the winter of 1888, and elsewhere, I urged with all the force at my command the advisability of endeavoring to introduce the natural enemies which were known to keep it in check in Australia. Certain indigenous species had been discovered preying upon it in California, and I expressed the belief that, as they increased, the fruit growers would get more and more relief from the Icerya; but I also urged that there was much more chance of success from those which keep it in check in its native home, and which were not imported with it to the countries of its introduction. The case was exceptional, and the attempt thus urged gave every promise of a rich reward. Efforts were made to introduce some of these natural enemies through correspondence, especially with the late F. S. Crawford, of Adelaide, with what ultimate results the subsequent success of Vedalia forever rendered uncertain.

The Hon. H. H. Markham, the present governor of California, was at that time a representative in Congress, and, through him chiefly, but also through others, I urged upon Congress the desirability of sending some one to Australia to make a thorough study of the subject, with a view of introducing those natural enemies. Again, in the winter of 1887–88 appeals were made to Congress, not only of a personal nature but through memorials, from various societies in California, for an appropriation to send one or two men to Australia to collect and increase these natural enemies. Congress, however, failed to make any specific appropriation, and also failed to remove the restriction in the appropriation to the division of entomology which limited traveling expenses to the United States and prevented independent action of the department. It happened, however, that about this time an appropriation was made and a commission created to represent the United States at the Melbourne Exposition, and, with the appreciative aid and sympathy of the Hon. Norman J. Colman, Commissioner of Agriculture, I took active steps to gain the co-operation of the Secretary of State in my pet scheme, and by an arrangement with the department of state, accepted by the commissioner to said exposition, Hon. Frank McCoppin, the department of agriculture was finally enabled to send to Australia two agents of the division of entomology; one of them to be under my instructions and the expenses of both, within the sum of $2,000, to be paid out of the appropriation for the aforesaid exposition.

It was thus that Mr. Albert Koebele, in the fall of 1888, was sent to Australia for this special purpose. The history of Mr. Koebele's efforts has been detailed from time to time in government publications and in the press, especially that of California. It suffices to state that a number of living enemies, both parasitic and predaceous, were successfully imported, but that one of them, *Vedalia cardinalis*, proved so effective as to throw the others entirely into the shade and render their services really unnecessary. It has, so far, not been known to prey upon any other insect, and it breeds with surprising rapidity, occupying less than 30 days from the laying of the eggs until the adults again appear. These facts account for its exceptionally rapid work, for in point of fact, within a year and a half of its first introduction, it had practically cleared off the fluted scale throughout the infested region. The expressions of two well known parties may be quoted here to illustrate the general verdict. Prof. W. A. Henry, director of the Wisconsin Agricultural Experiment Station, who visited California in 1889, reported that the work of the vedalia was "the finest illustration possible of the value of the department to give the people aid in time of distress, and the distress was very great indeed." Mr. Wm. F. Channing, of Pasadena, son of the eminent Unitarian divine, wrote two years later:

"We owe to the Agricultural Department the rescue of our orange culture by the importation of the Australian ladybird, *Vedalia cardinalis*.

"The white scales were incrusting our orange trees with a hideous leprosy. They spread with wonderful rapidity and would have made citrus growth on the whole North American continent impossible within a few years. It took the Vedalia, when introduced, only a few weeks absolutely to clean out the white scale. The deliverance was more like a miracle than anything I have ever seen. In the spring of 1889 I had abandoned my young Washington Navel orange trees as irrecoverable. Those same trees bore from two to three boxes of oranges apiece at the end of the season (or winter and spring of 1890). The consequence of the deliverance is that many hundreds of thousands of orange trees (Navels almost exclusively) have been set out in Southern California this last spring."

In other words, the victory over the scale was complete and will practically remain so. The history of the introduction of this pest, its spread for upward of twenty years and the discouragement which resulted, the numerous experiments which were made to overcome the insect and its final reduction to unimportant numbers by means of an apparently insignificant little beetle imported for the purpose from Australia, will always remain one of the most interesting stories in the records of practical entomology.

The Vedalia has since been successfully colonized at the Cape of Good Hope and in Egypt, and has produced the same results in each case. In Egypt the Vedalia was introduced to prey upon an allied species of Icerya (*I. ægyptiacum*, Douglas). We hope soon to be able to send the same insect to India, where it has recently transpired that *Icerya ægyptiacum* occurs, while recent information received from Phra Suriya, royal commissioner of Siam at Chicago, would indicate that its introduction into Siam for the same or a closely allied insect will be desirable in the near future.

In fact, the success of the experiment was so striking and so important and resulted in the saving to California of an industry of so great a money value, that it has given rise, not only in the popular mind, but in the minds of a certain class of entomologists also, to the idea that remedial work against injurious insects should be concentrated upon this one line of action, and that our best hope for their destruction lies with the parasitic and predaceous species, not to mention fungus and bacterial diseases. From an extreme of comparative incredulity the farmer and fruit grower have gone, perhaps, to the other extreme of too great faith. The case of Icerya and Vedalia, as I have frequently pointed out, was exceptional and one which cannot easily be repeated.

One of the numerous phases of the Vedalia experiment is that the wide newspaper circulation of the facts—not always most accurately set forth—has brought me communications from all parts of the world asking for supplies of the renowned little ladybird for use against injurious insects of every kind and description, the inquiries being made, of course, under a misapprehension of the facts.

While this California experience thus affords one of the most striking illustrations of what may be accomplished under exceptional circumstances by the second method of utilizing beneficial insects, we can hardly expect to succeed in accomplishing much good in this direction without a full knowledge of all the ascertainable facts in the case and a due appreciation of the profounder laws of nature, and particularly of the interrelations of organisms. Year in and year out, with the conditions of life unchanged by man's actions, the relations between the plant feeder and the predaceous and parasitic species of its own class remain substantially the same, whatever the fluctuations between them for any given year. This is a necessary result in the economy of nature, for the ascendency of one or the other of the opposing forces involves a corresponding fluctuation on the decreasing side, and there is a necessary relation between the plant feeder and its enemies, which, normally, must be to the slight advantage of the former and only exceptionally to the great advantage of the latter. This law is recognized by all close students of nature and has often been illustrated and insisted upon by entomologists in particular, as the most graphic exemplifications of it occur in insect life, in which fecundity is such that the balance is regained with marvelous rapidity, even after approximate annihilation of any particular species. But it is doubtful whether another equally logical deduction from the prevalence of this law has been sufficiently recognized by us, and this is, that our artificial insecticide methods have little or no effect upon the multiplication of an injurious species, except for the particular occasion which calls them forth, and that occasions often arise when it were wiser to refrain from the use of such insecticides and to leave the field to the parasitic and predaceous forms.

It is generally when a particular injurious insect has reached the zenith of its increase and has accomplished its greatest harm, that the farmer is led to bestir himself to suppress it, and yet it is equally true that it is just at this time that nature is about to relieve him in striking the balance by checks, which are violent and effective in proportion to the exceptional increase of, and consequent exceptional injury done by, the injurious species. Now the insecticide method of routing this last, under such circumstances, too often involves, also, the destruction of the parasitic and predaceous species, and does more harm than good. This is particularly true of those of our Coccidæ and Aphididæ and those of our lepidopterous larvæ which have numerous natural enemies of their own class; and it not only emphasizes the importance of preventive measures which we are all agreed to urge for other cogent reasons, and which do not to the same extent destroy the parasite, but it affords another explanation of the reason why the fight with insecticides must be kept up year after year and has little cumulative value.

But the problem of the wise encouragement and employment of the natural enemies of injurious insects in their own class is yet more complicated. The general laws governing the interaction of organisms are such that we can only in very exceptional cases derive benefit by interference with it. The indigenous enemies of an indigenous phytophagous species will, *caeteris paribus*, be better qualified to keep it in check than some newly introduced competitor from a foreign country, and the peculiar circumstances must decide in each case the advisability of the introduction. The multiplication of the foreigner will too often involve the decrease of some indigene. If a certain phytophage is generally disastrous in one section and innocuous in another, by virtue of some particular enemy, it will be safe to transfer and encourage such enemy, and this is particularly true when the phytophage is a foreigner and has been brought over with the enemy which subdues it in its native home. Icerya had some enemies in California, presumably American, but they were not equal to the task of subduing it. Vedalia in the Icerya's native home, Australia, was equal to the task and maintained the same superiority over all others when brought to America. The genus was new to the country, and the species had exceptionally advantageous attributes. But there is very little to be hoped from the miscellaneous introduction of predaceous or parasitic insects for the suppression of a phytophage which they do not suppress in their native home or in the country from which they are brought. The results of the introduction by Mr. A. D. Hopkins of *Clerus formicarius* to contend with the Scolytids, which were ruining the West Virginia pines, were doubtful for the reason that the indigenous species of the genus were already at work in America. Yet the experiment was safe and desirable, because the European Clerus is more active and more seemingly effective than our indigenes. The gypsy moth was evidently introduced into Massachusetts without its European natural enemies, and, as in some parts of Europe, it is often locally checked by such natural enemies, a great number of which are known, a proper study of them and the introduction of the most effective could result in no possible harm, and might be productive of lasting good. Such a course was advised by me at a conference upon the subject to which I was invited and which was held in the rooms of the State Board of Agriculture, Boston, March 4, 1891,* and in correspondence with the secretary of the board. In neither of these cases should we expect the predaceous or parasitic forms to subdue their hosts more effectually in America than they do in Europe, except in so far as they were relieved in the introduction into America of whatever enemies they possess in their native home.

There are two other laws which it is worth while to consider in this connection. One is, that while a plant feeder's natural enemies are apt to cause its excessive abundance to be followed by a corresponding decrease, yet this alternation of excessive abundance and excessive scarcity will often be produced irrespective of such natural checks. An injurious insect, which has been on the destructive march for a period of years, will often come to a sudden halt and a period of relative and sometimes complete immunity from injury will follow. This may result from climatic conditions, but more often it is a consequence of disease, debility and want of proper nutrition, which are necessary corollaries of undue multiplication. Frequently, therefore, it may be inaccurate and misleading to attribute the disappearance of a particular injurious species to some parasitic or predaceous species which has been let loose upon it, and nothing but the most accurate observation will determine the truth in such cases. The past year furnished a very graphic illustration in point. Throughout Virginia and West Virginia, where the spruce pines have for some years suffered so severely from the destructive work of *Dendroctonus frontalis*, not a single living specimen of the beetle has been found during the present year. This has been observed by every one who has investigated the subject, and particularly by several correspondents who have written to me; by Mr. E. A. Schwarz, who was commissioned to investigate the facts, and by Mr. Hopkins, who has made the study of the subject a specialty. The clearest explanation of this sudden change is that the species was practically killed out by the exceptionally severe cold of last winter, since such was the case with several other insects. Now, following so closely on the introduction by Mr. Hopkins of *Clerus formicarius*, how easy it would have been to attribute the sudden decrease to the work of the introduced Clerus had not the decrease been so general and extensive as absolutely to preclude any such possibility. In like manner a certain scale insect (*Aspidiotus tenebricosus*) had become exceedingly destructive to the soft maples in the city of Washington last year, whereas the present year it is almost entirely killed off, evidently by the same exceptional cold. Many of the affected trees were painted with whitewash, with a view of destroying the Aspidiotus, and the death of this last might have been attributed to the treatment (and naturally would be by those employing it) were it not that the same result was equally noticeable on the trees not treated. Reports from Southern California would indicate that the red scale (*Aspidiotus aurantii*) is, in many orchards, losing its destructiveness through agencies other than its insect enemies, and in this case the facts are particularly interesting, because of the ease with which its disappearance may be attributed to some of the recent introductions from Australia.

The other law that is worth considering in this connection is, that experience has shown that, as a rule, the animals and plants of what is known as the "Old" World—*i. e.*, of Europe and Asia—when introduced into North America, have shown a greater power of multiplication than the indigenous species and in a large number of instances have taken the place of the native forms, which have not been able to compete with them in the struggle for existence. This converse proposition holds equally true, viz., that our species, when taken to Europe, do not hold their own against the European indigenes. This is still more true of the species introduced from the Old World, as well as from America, into Australia, where the advantage of the introduced forms, as compared with the indigenes, has been in many cases still more marked. All other things being equal, we should expect the species which

* Insect Life, iii, p. 369, ff.

are beneficial in Australia to be less so when brought to this country; a deduction which brings out still more clearly the exceptional nature of the case of Vedalia and Icerya, just as there are some notable exceptions, as in the case of the grape phylloxera, in the introductions from America to Europe.

There are some instances in which there can be no doubt whatever as to the good which will flow from the introduction of beneficial species, and an illustration is afforded in the Caprifig insect, *Blastophaga psenes*. There can be no question as to the good which would result from the introduction of this species from Smyrna into those sections of California where the Smyrna fig is grown without its intervention, and there are other similar instances which promise well and involve no risk. But I have said enough to show that the successful utilization of beneficial insects is by no means a simple matter, and that discriminating knowledge is required to insure success or prevent disaster, especially in the second category dealt with in this paper. The danger attending introductions of beneficial species by unconsciously accompanying them with injurious forms, or by failure to appreciate the facts here set forth, is well illustrated by the introduction to Europe of our *Peronospora viticola*, of the English sparrow to America, and of the mongoose to Jamaica.

Wherever the importance of the matter leads to legislation, what are denominated "political" methods are apt either to control or in some way influence the resulting efforts—too often with unfortunate consequences. We should, as economic entomologists, be on the alert for the special cases where the introduction or dissemination of beneficial species promises good results, and do our best to encourage an intelligent public appreciation of such special cases, while discouraging all that is of unscientific or sensational nature, as likely to mislead and ultimately do our profession more harm than good.

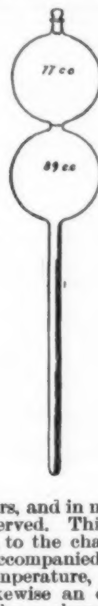
CHANGE OF VOLUME WHEN LIQUIDS OF DIFFERENT DENSITIES ARE MIXED.*

By WILBUR S. SCOVILLE.

FROM time to time articles appear in our text books, journals, and proceedings, offering a rule whereby liquids of different densities may be mixed to obtain any desired intermediate density. These rules are necessarily limited to those liquids which neither contract nor expand when mixed, but the fact has apparently been overlooked that such liquids are rare rather than common.

It has been known for some time that solutions of salts contract when diluted, or, in other words, if an aqueous solution of a salt be diluted with water, the volume of the mixture is generally less than the sum of the volume used in producing it. The same is generally true of indifferent liquids, though in a few cases expansion occurs rather than contraction, and in some no change in volume can be observed.

At the same time that this change in volume occurs, a slight change in temperature also takes place. There is commonly an elevation of temperature, but some-



times a lowering occurs, and in many cases no change in temperature is observed. This change in temperature bears no relation to the change in volume, since contraction may be accompanied by either an elevation or lowering of temperature, or with no change in temperature, and likewise an expansion in volume may be accompanied by a change in temperature in either direction, or with none at all.

In the present paper no attempt has been made to measure the changes in temperature, the object being only to call attention to the changes in volume which occur, to show how nearly universal this change is, and to demonstrate that it is of sufficient extent to render void the use of specific gravity rules, in most cases, for anything except approximate results.

To illustrate, a mixture of glycerin and water in the proportions and quantities used in the table appended, contracts 2·0 c. c., which may be taken as a mean of the contractions. The calculated gravity of such a mixture, provided no contraction takes place, would be 1·1369 (approx.), [89 c. c. × 1·2554 = 111·73 G. + 77 = 188·73 ÷ 166 = 1·1369]. But the contraction changes the quantity to 1·1508 (approximate), (188·73 ÷ 164 = 1·15079), a difference of two in the second decimal, which is verified by trial.

The apparatus by which the contractions were measured consisted of a double bulb of glass, the lower of which bulbs was extended into a tube 15 cm. long, graduated to hold 10 c. c. in $\frac{1}{10}$ c. c.; 0·05 c. c. could be read easily in this tube. The upper bulb was fitted with an accurately ground stopper, the two bulbs connecting at opposite sides. In using it, the lower tube and bulb was completely filled with the heavier liquid at 20° C., by means of a long stem funnel, then the lighter liquid flowed into the upper bulb, which was filled to the brim, so that insertion of the stopper displaced a part of this liquid, and no air space was left in the apparatus.

The liquids were then mixed by inverting the apparatus and shaking, placed in a water bath kept at 20° C. until this temperature was uniform in the apparatus, then the contractions read upon the graduated tube. The lower bulb and tube held 89 c. c., the upper bulb 77 c. c.

It was better for appearance sake to have used an apparatus holding equal volumes of each liquid; but as the only object was to show that there is a change of volume in most cases, and as an accurate table showing the extent of such change would be of little or no practical value, no attempt was made to construct such a table.

The common solvents and most soluble salts used in pharmacy were selected for experimentation, the salts being used in aqueous solution, nearly saturated. Gravities were all taken at 15° C.; the liquids mixed and contractions read at 20° C.

The results are given in the following table:

Heavier Liquid.	Spec. grav.	Lighter Liquid.	Spec. grav.	Contraction.
Acid, Acetic Glacial	1.0615	Water	1.0000	5 c.c.
Acid, Citric	1.2620	"	1.0000	0.5 c.c.
Acid, Hydrobromic	1.2364	"	1.0000	None.
Acid, Hydrochloric	1.1754	"	1.0000	0.75 c.c.
Acid, Nitric	1.4210	"	1.0000	6.45 c.c.
Acid, Tartaric	1.3205	"	1.0000	0.8 c.c.
Alcohol	.8199	Ether	.7279	1.85 c.c.
Alum	1.0515	Water	1.0000	Very slight.
Ammonia Water	.8977	"	1.0000	None.
Ammonium Chloride	1.0705	"	1.0000	0.35 c.c.
Calcium Chloride	1.3070	"	1.0000	1.2 c.c.
Carbon Bisulphide	1.2711	Benzine	.6975	None.
Carbon Bisulphide	1.2711	Cotton Seed Oil	.9329	None.
Chloroform	1.4896	Ether	.7279	2.1 c.c.
Chloroform	1.4896	Oil Turpentine	.8751	Slight expansion.
Chloral	1.3615	Water	1.0000	0.6 c.c.
Copper Sulphate	1.2077	"	1.0000	0.5 c.c.
Glycerin	1.2554	"	1.0000	2.0 c.c.
Iron Sulphate	1.2405	"	1.0000	0.6 c.c.
Magnesia Sulphate	1.2862	"	1.0000	1.2 c.c.
Oil Turpentine	.8751	Ether	.7279	0.5 c.c.
Potass. Bicarbonate	1.1587	Water	1.0000	0.45 c.c.
Potass. Bromide	1.3557	"	1.0000	0.35 c.c.
Potass. Carbonate	1.4281	"	1.0000	2.55 c.c.
Potass. Iodide	1.6440	"	1.0000	0.55 c.c.
Potass. Nitrate	1.1377	"	1.0000	0.25 c.c.
Sodium Carbonate	1.2281	"	1.0000	1.15 c.c.
Sodium Chloride	1.2052	"	1.0000	0.7 c.c.
Sodium Salicylate	1.1942	"	1.0000	0.7 c.c.
Sodium Sulphate	1.1108	"	1.0000	0.3 c.c.
Soda (caustic)	1.4867	"	1.0000	6.8 c.c.
Syrup	1.3462	"	1.0000	0.45 c.c.
Zinc Sulphate	1.4717	"	1.0000	1.7 c.c.
Water	1.0000	Alcohol	.8199	4.65 c.c.

*Read at the forty-first annual meeting of the A. P. A.—*Western Druggist.*

THE CHEMISTRY OF BACTERIA.*

By R. WARINGTON.

THE immense variety of substances produced in the vegetable kingdom has always been a source of astonishment to the chemist. The plant is, indeed, the finest chemical laboratory with which we are acquainted. While some kinds of chemical work are common to all plants, there is hardly a species which does not possess some special capacities—which does not produce some products different from its neighbors. When we survey the whole vegetable kingdom, the extent to which this specialization is carried, and the immense variety of the products obtained, become simply overwhelming. Chemists are still unacquainted with the larger part of the substances produced by plants. When we turn from the products of plant work to the materials employed our wonder still increases, for these materials are of the simplest kind—water, carbonic acid gas, oxygen, nitric acid, and a few inorganic salts—yet out of these the whole of the immense variety of vegetable products is constructed.

This being the case, we need hardly say that the methods of plant chemistry are of supreme interest, both to the chemist and to the vegetable physiologist. By the aid of what forces, through what course of reactions, are the simple materials moulded to their final issue? The higher plants are in some respects unfavorable subjects for the study of plant chemistry. Their different parts have different functions, and the changes in progress are obscured to the student by the fact that changes of a very different type are in progress at the same time, and in places very near to each other. What would not the physiologist give if he could isolate a single cell, and grow it by itself in solutions of known composition; when by studying the nature of the cell's new growth, and the variations taking place in the nourishing solution, he might hope to be able to grasp the facts of cell nutrition and the nature of its waste products? Such an opportunity is actually afforded when we study the chemical changes brought about by bacteria.

In bacteria we have the vegetable cell in its simplest form; we have a mass of protoplasm and a cell wall, but the cell is single or united with a few others, and, as far as we know, the life changes in all the cells of every species living under the same conditions are the same. Moreover, these organisms grow freely in suitable solutions, and the chemical changes produced in the materials held in these solutions can be readily ascertained. We have thus in a study of the chemistry of bacteria a splendid opportunity for enlarging our knowledge of plant chemistry, and, indeed, of becoming acquainted with the fundamental reactions on which synthetical organic chemistry depends.

The study of the chemical work performed by bacteria has occupied as yet but a few years, but the results have been most remarkable. The immensely numerous species of bacteria have been found to exhibit an almost equally great diversity of action. Different members of the class have been found to flourish under entirely opposite conditions, to feed on wholly different materials, to perform an immense variety of chemical work upon the media in which they live, and yet the chief product of plant life—the formation of protoplasm and cell wall—is probably in each case practically the same. The study of the chemistry of bacteria has thus greatly enlarged our conceptions of the chemical power of the vegetable cell.

As a contribution to the discussion to-day, I propose to call attention to the chemical actions displayed by three species of bacteria existing in the soil, and all of first-class importance in their relations to agriculture.

It is well known that all ordinary soils contain organisms possessing a vigorous power of oxidizing—of bringing about a combination between the oxygen of the air and various organic and inorganic bodies. Thus dead vegetable and animal tissues in soil are, under favorable conditions of heat and moisture, resolved into carbonic acid, water and nitric acid.

Particular experiments show that the nitrogen of albumin, gelatin, asparagin, urea, ammonia, ethylamine, and thiocyanates is converted by soil into nitric acid. Nor is the action confined to organic matter; for nitrites are oxidized to nitrates, iodides to hypoiodites and iodates, and bromides to hypobromites and bromates.

The organisms producing nitric acid have been made the subject of study by many chemists, and after much labor and many disappointments they have been satisfactorily isolated.

We now know that the production of nitrates in the soil—a process of the greatest importance for the nutrition of agricultural crops—is accomplished by the action of two organisms, each of which performs a distinct stage in the work. By one organism ammonium carbonate is oxidized and the nitrogen converted into a nitrite. By the second organism nitrites are converted into nitrates. We have here an excellent example of the way in which certain special functions, certain narrowly limited lines of work, are exercised by individual species of bacteria. The nitrous organism can oxidize ammonia to nitrite, but it cannot change a nitrite into a nitrate. The nitric organism, on the other hand, oxidizes nitrites readily, but it cannot oxidize ammonia. Both organisms are present in all fertile soils, but the formation of nitrites is not usually perceived, as they are at once converted into nitrates.

The organisms we have mentioned grow and exercise their functions in dilute solutions of appropriate composition, and it is therefore possible to study exactly the mode of their nutrition.

Like every other living organism, they develop and perform their functions only when certain inorganic salts supplying phosphates, sulphates, potassium, calcium, and magnesium are present. The continued omission of one of these has been proved in several cases to bring about a cessation both of growth and function. The general fact is familiar to physiologists, but it is singular that we have as yet no rational idea of the mode in which these various inorganic bodies assist in plant nutrition, with the exception of the fact that sulphur, and possibly in some cases phosphorus, are constituents of albuminoid bodies.

As to nitrogenous food, these organisms are amply furnished by the ammonia, the nitrite, or nitrate which is intentionally added to the solution; the addition of no other nitrogenous substance is necessary. Here, too, we are on familiar ground. Ammonia and nitrates are both well known as the most appropriate nitrogenous food for plants.

When we inquire, however, what is the source of carbon to the nitrifying organisms, we are confronted by a startling novelty. It is found to be quite unnecessary to supply these organisms with any carbonaceous food save carbonates, bicarbonates being preferred. The fact of the conversion of carbonates into organic cell substance has been conclusively proved in the case of the nitrous organism; it is at present assumed to be also true of the nitric organism, as this also requires the addition of no organic carbon to its nutritive solution.

The fact that green plants exposed to sunlight are capable of forming organic substances from the carbonic acid and water of the atmosphere is well known to physiologists, but it is equally certain that this action does not occur in the dark. Yet here we have a colorless cell, destitute of chlorophyl, growing in the dark, which, nevertheless, is capable of decomposing carbonic acid, and producing from it carbonaceous cell substance. From a purely chemical point of view this reaction may well appear at first sight incredible, as the decomposition of carbonic acid is an action requiring the consumption of much energy, which in the case of the green plant is supplied by the sun's rays, but in the case of the nitrifying organism is supplied in no such way.

This theoretical difficulty disappears, however, when we look at the whole reaction brought about by the nitrous organism. This organism attacks carbonic acid in its combination as ammonium carbonate, and the formation of an organic carbon compound proceeds at the same time as the oxidation of the ammonia; the result of the whole reaction being the liberation of heat, and not its consumption. A supply of external energy is thus not required.

Expressed in its simplest terms, the green plant manufactures carbohydrates from carbonic acid and water by a consumption of solar energy as follows:

$$CO_2 + H_2O = CH_2O + O_2.$$

The nitrous bacterium oxidizes ammonium carbonate, producing at the same time ammonium nitrite and a carbohydrate; this reaction we may express in its simplest form as follows:

$$(NH_4)_2CO_3 + O = NH_4NO_2 + CH_2O + H_2O.$$

The equation, however, by no means fully expresses what actually occurs, as Winogradsky finds that 35 parts of nitrogen as ammonia are oxidized for one part of carbon assimilated; the whole reaction is thus strongly exothermic.

The nitric organism multiplies more slowly than the nitrous, and does not therefore afford so good a subject for quantitative experiments; its nutrition has not yet been fully studied.

The last organism I wish to speak of is the one of which Winogradsky has given a preliminary description during the past summer. It has been obtained from soil, and possesses the remarkable power of assimilating the free nitrogen of the atmosphere. To accomplish this assimilation it is simply necessary to grow it in a solution containing sugar (dextrose) and the necessary salts, no combined hydrogen being supplied. Under these circumstances a vigorous growth of the bacillus takes place, the sugar undergoes a butyric fermentation, and at the end of the operation it is found that the culture has acquired nitrogen, the amount being apparently about one five-hundredth of

*A paper read before a conference of Sections B and D, Nottingham meeting, 1893.—*Chem. News.*

the weight of the sugar fermented. By using as much as 7 grammes of sugar, an assimilation of 14 milligrammes of nitrogen has been obtained. Washed air, free from ammonia and nitrates, was used in these experiments.

That a vegetable organism should be able to acquire from the air the whole of the nitrogen which it needs is certainly very remarkable, and is an extraordinary fact, both to the physiologist and chemist.

We have no clew as yet to the mode in which the nitrogen enters into combination; but it is evident that in this case, as in the nutrition of the nitrous organism, the difficult piece of chemical work forms but a small part of a much larger reaction that is at the same time in progress, and with which it is essentially connected.

It seems not improbable that these results of Winogradsky will explain some facts which have hitherto presented much difficulty. That a special organism, when in union with the roots of a leguminous plant, is capable of bringing about the assimilation of the free nitrogen of the air is now admitted by all; but it is denied by Schloesing and other accurate observers that the same organism when living in the soil has any such property. May we not suppose that for the assimilation of nitrogen to occur the organism must be supplied with sugar or its equivalent, and that this supply of sugar to the organism only takes place when the organism gains access to the sap of one of the higher plants.

In conclusion, I think we shall all agree that, however imperfect is our knowledge of the chemistry of the three species of bacteria we have considered, the facts which have been established have at least enlarged our conception of the capabilities of a vegetable cell, and I trust that some light has also been thrown on the general method by which some of the extraordinary chemical results are attained.

ON THE DIAMOND IN THE CANON DIABLO METEORIC IRON AND ON THE HARDNESS OF CARBORUNDUM.

By GEORGE FREDERICK KUNZ and OLIVER W. HUNTINGTON, Ph.D.

THE discovery of diamonds in the Canon Diablo meteoric iron was first announced by Dr. A. E. Foote in this journal for July, 1891 (vol. xlii., pp. 413-417). He found in the cutting of this meteorite that it was of extraordinary hardness, a day and a half of time being consumed and chisels destroyed in the process of removing a section. In cutting, the chisels had fortunately gone through a crevice filled with small cavities. The emery wheel used to polish this surface was ruined, and on examination the exposed cavities were found to contain hard particles which cut through polished corundum as easily as a knife cuts gypsum. The grains exposed were small and black, and Professor George A. Koenig pronounced them diamonds because of their hardness and indifference to chemical agents. The extreme hardness was subsequently verified by one of us (G. F. Kunz), who carefully examined the type specimen.

On July 8, 1892 (*Science*, p. 15), Dr. Oliver Whipple Huntington gave the result of his experiments with this remarkably interesting Canon Diablo iron. Taking 100 grammes of the iron he placed it in a perforated platinum cone suspended in a platinum bowl filled with acid, the cone being made the positive pole and the dish the negative pole of a Bunsen cell. The iron was slowly dissolved, leaving on the cone a large amount of black slime. This was carefully collected, digested over a steam bath for many hours, first with aqua regia and afterward strong hydrofluoric acid. A considerable part of the residue disappeared, but there remained a small amount of white grains which resisted the action of the acids. These particles, when carefully separated by hand, had the appearance of fine beach sand. Under the microscope they were found to be transparent and of brilliant luster. One of the grains was then mounted upon a point of metallic lead, which, when drawn across a watch crystal, was found to give the familiar singing noise characteristic of a glass cutter's tool and with the same result, namely, cutting the glass completely through. It deeply cut glass, topaz and a polished sapphire. These facts, first announced in *Science*, April 8, 1892, were presented at the meeting of the American Academy of Arts and Sciences on May 11, 1892, and were published in the Proceedings of this Academy, new series, vol. xxii., pp. 252, 253.

Later M. C. Friedel says in the *Bulletin de la Societe Francaise de Mineralogie*,* that he took a fragment of the Canon Diablo meteorite weighing 34 grammes, which gave the characteristic Widmannstattian figures, and treated it with hydrochloric acid. He digested the residue in aqua regia and obtained a black powder. After various treatments he thus separated about 0·35 gramme of a powder, which he presented to the Academy. The powder sank in a solution of the iodide of methyl, having a density of 3·3. No grains measuring more than 0·5 mm. to 0·8 mm. were found, the powder being fine and impalpable, capable of scratching corundum. He also burned some of the black residue, and as a product obtained CO_2.

At the meeting, above referred to, of the Academy of Arts and Sciences, Dr. Huntington showed to the members, under a microscope, the slightly yellow transparent grains he had obtained, and called attention to their adamantine luster. Not enough of the clear material was obtained at the time for a chemical test, and, on account of the association of the diamond grains with amorphous carbon, such a test would not have been conclusive without a perfect mechanical separation. One of us (G. F. Kunz) suggested that, if enough of the clear grains could be obtained to polish a diamond, it would conclusively prove that the material was diamond. For this purpose about 300 pounds of the meteoric iron was carefully examined, and specimens which appeared to contain diamonds were dissolved. The method used will be published by one of us (O. W. Huntington) later. After enough material had been separated by Dr. Huntington, on Monday, September 11, 1893, through the courtesy of Messrs. Tiffany & Co., we were enabled to try the desired experiment in their diamond cutting pavilion in the Mining building of the World's Columbian Exposition, they having prepared a new skaif or wheel, measuring 10½ inches in diameter, which was placed in position, the wheel having been specially planed down and prepared with the radiating scratches so as to be easily charged with diamond powder. A diamond was then soldered in a metal dopp and placed on the clean wheel, which made 2,500 revolutions to the minute. This diamond was tried for more than five minutes by itself without the slightest polish being produced and no markings other than such as would be produced by the minute shattering of the diamond at extreme edges, due to the friction, as when a diamond is placed on an uncharged wheel. At 9.20 a cleavage, weighing five thirty-seconds of one carat, was set with solder in the metal dopp, which was placed on the wheel. The diameter of the wheel where the diamond was to be placed was four inches. The wheel was then charged with the residue from the meteorite (the powder mixed as usual with oil). The moment that the diamond was placed on the wheel a hissing noise was apparent, showing to an expert that the material was really cutting the diamond. At 9.23 a flat surface, measuring 3 mm. by 1 mm. had been ground down and polished. At 9.30 a small crystal with a natural face up was set in the metal dopp, the crystal being a small natural complex twin weighing four thirty-seconds of one carat. It was first tried on a projecting angle. The cutting was very slow for a time, as the natural face of a diamond is always exceedingly hard. The position of the stone was then slightly changed, and a face measuring 2 mm. by 1 mm. was ground on the stone and cut. Three minutes later the surface had been cut down somewhat and a decided polish was produced on the triangular face, which was 3 mm. by 1·25. The fragment used was one of the octahedral faces of a crystal. The face ground down was at the angle of 45° with the octahedral face. The entire time of this experiment was 15 minutes. The two experiments having been made with great care with both of us present, we cannot hesitate to pronounce the material diamond or a substance with the same hardness, color, luster and brilliancy.

In August last, one of us (G. F. Kunz) while examining the hardness of "carborundum," a carbide of silicon, made by Mr. Acheson, of Pittsburg,* it was found that it readily scratched red, blue, white, pink and yellow corundum in the form of fine gems. It having been suggested that this material would cut and polish a diamond, an experiment was made on a new wheel. After several trials had been made, it was found that carborundum would not scratch or polish the diamond, but on the other hand it was easily scratched by diamond cleavages and crystal faces. This experiment is only mentioned, as it precludes any possibility of the material which has been found in the Canon Diablo meteorite being any such compound of carbon and silicon, such as the new and interesting abrasive material just mentioned. But it establishes the fact that we have an artificial substance that exceeds all natural substances except the diamond in hardness, *i.e.*, being harder than 9, but still far distant from 10.—*Am. Jour. of Science, Dec.*

* No. 9, p. 258, December, 1892.

* See *Engineering and Mining Journal*.

CAFFEARINE.—A new alkaloid was isolated from coffee by D. P. Palladine by repeatedly boiling the raw coffee (in as fine a condition as possible) with ten times its weight of water, to which a little milk of lime was added; the decoctions are precipitated with solution of lead subacetate in slight excess, filtered, the excess of lead removed by adding sulphuric acid and the solution concentrated; should the solution show considerable color, the precipitation with lead subacetate is to be repeated; the caffeine is removed by extracting with 10–12 portions of chloroform or until nothing more is removable. The solution is acidified with sulphuric acid and evaporated several times to volatilize the acetic acid, after which the aqueous solution is decolorized by animal charcoal; the caffearine is next precipitated by potassio-bismuth iodide, the precipitate carefully washed, suspended in water, and decomposed with hydrogen sulphide, the hydriodic acid neutralized with lead carbonate, filtered, and the precipitation with potassio-bismuth iodine, etc., repeated until the precipitate shows a beautiful crystalline appearance; after decomposing with hydrogen sulphide the solution of the hydroiodate is warmed in a water bath with silver oxide, carefully neutralized with hydrochloric acid and the hydrochlorate allowed to crystallize. The alkaloid itself, $C_{14}H_{16}N_2O_4$, can be obtained from the hydrochlorate by the use of silver oxide, and is obtainable in crystalline needles, which are acted upon by light, and are quite soluble in water and alcohol. The hydrochlorate, $C_{14}H_{16}N_2O_4\ HCl + H_2O$, forms needles extremely soluble in water, also soluble in dilute alcohol, but insoluble in absolute alcohol. Caffearine differs from caffeine by being precipitable by alkaloidal reagents.—*Apotheker Ztg.; Amer. Jour. Pharm.*

STRUCTURE OF YEAST CELLS.

IN connection with the claim of Dangeard (*ante*, p. 83) to have proved the existence of well-characterized nuclei in the *Saccharomyces cerevisiæ*, it may be noted that other recent investigators have not attained similar results. G. Hieronymus (*Ber. deutsch. bot. Gesell.*) finds the contents of yeast cells to present a similar fibrillar structure to that seen in the *Phycochromaceæ*. Angular granules lying in the protoplasm probably consist of nuclein, and are always arranged in rows intertwined into a more or less regular spiral or ball, which is distinguished as the central thread. J. Raum (*Zeit. f. Hygiene*) also failed to find true nuclei present in yeast cells, but found, when the conditions of nutrition were favorable, bodies known as sporogenic granules in the ten species he examined. The granules exhibit great variation, and, as no membrane or any definite structure could be observed in them, are probably of fluid consistence. They are digestible by pepsin, and may, therefore, be of the nature of nuclein. Vacuoles were also frequently present in the cells, of a size in inverse ratio to that of the granules, but in kephir yeast they were absent.—*Jour. R. M. S.*

ELECTROLYTIC INDICATOR.—Moisten paper with a solution of 50 grammes of glycerine, 20 grammes of distilled water, 3 grammes of potassium nitrate, and 0·05 gramme of phenolphthalein. By touching the ends of both wires, the negative pole is indicated by becoming of a reddish violet color.—*Rev. Chem.*

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